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Preliminary Draft

Coeur d'Alene Basin Remedial ~~Investigation/Feasibility Study~~

July 2000

Prelim. Draft EcoRA

Text

URS Greiner

in association with

CH2M HILL

White Shield, Inc.

151189

Post Falls dam → Post Falls Dam
Upriver Dam → Upriver Dam

DRAFT
REMEDIAL INVESTIGATION REPORT

COEUR D'ALENE BASIN REMEDIAL INVESTIGATION/FEASIBILITY STUDY

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1.0 Introduction

EXECUTIVE SUMMARY

The Executive Summary will be prepared for the August draft submittal.

1.0 INTRODUCTION

The project area includes the CdA River basin, associated tributaries. CdA Lake and downstream Spokane River to Fort Spokane or the Spokane Arm of the Lake

1.1 OBJECTIVE AND SCOPE

This section presents the results of the ecological risk assessment (EcoRA) for aquatic and terrestrial organisms potentially exposed to hazardous wastes associated with mining activities in the Coeur d'Alene River basin in Idaho, ~~and Washington~~ (Figure 1-1). This EcoRA has been prepared to support the Coeur d'Alene River basin Remedial Investigation/Feasibility Study (RI/FS). The overall objective of the EcoRA ~~is~~ to provide a quantitative and qualitative appraisal of the actual or potential effects of mining-related hazardous wastes on plants and animals (other than humans and domesticated species). This assessment will help risk managers to determine whether remedial action is needed and, if so, the scale required.

The EcoRA evaluates potential threats to the environment in the absence of any remedial action (the no-action alternative). It identifies and characterizes the toxicity of chemicals of potential ecological concern (COPECs), possible exposure pathways, potential ecological receptors, assessment and measurement endpoints, and a range of possible risks under the conditions defined for the site.

need to include a name reference and location for CSM 1, 2, 3

check

1.2 GUIDANCE

The no-action alternative assumes that no corrective action will take place and that future land use will be similar to current use. The EcoRA addresses potential risks within the Coeur d'Alene River basin under current and reasonable future land uses. It addresses the five Coeur d'Alene River basin conceptual site model (CSM) units that were differentiated based on geomorphology, mixes of hazardous substances, habitats, and ecological receptors (USEPA 1999). These CSM units are discussed in Section 2.5 and are briefly described below.

CSM Unit 1 contains many of the primary sources for hazardous substances (metals) including active and inactive mines, mills, smelters, and waste piles. The primary sources within this CSM unit include mine workings, waste rock and other mining waste, mine tailings, concentrates, and other process wastes, and artificial fill (tailings and waste rock in roads, railroads, and building foundations).

CSM Unit 2 contains the remainder of the primary sources of mining-related hazardous substances within the surface water and sediments of mid-gradient streams and small tributaries within the Coeur d'Alene River watershed. The primary sources within this CSM unit include mine workings, waste rock, tailings, concentrates, and other process wastes, and artificial fill areas.

CSM Unit 3 consists of the low-gradient part of the Coeur d'Alene River from the Old Highway Bridge at Cataldo to Coeur d'Alene Lake. The primary sources within this CSM unit include dredge spoils and highway/railway beds constructed from mining wastes. Secondary sources within this CSM include contaminated floodplain soils and sediment, surface water, groundwater, and biota. — should this be identified as a source?

CSM Unit 4 consists of Coeur d'Alene Lake divided into three sections: southern, mid-to-northern, and Wolf Lodge Bay. The primary sources within this CSM unit include contaminated sediments and surface water. In addition, nutrients are a significant concern because they can change the trophic status of the lake and cause secondary releases of metals from contaminated sediments.

CSM Unit 5 consists of the Spokane River. The primary sources within this CSM unit are contaminated sediments and surface water.

need to qualify this because we know actions ARE taking place

1.3 ASSUMPTIONS

This evaluation is based on the following major assumptions and constraints:

- No remedial action will be taken (i.e., the no-action alternative).
- The abiotic media of primary ecological concern are surface water, sediment, and soil (within 5 feet of ground surface).
- Chemical data were evaluated based on the habitat type in which the samples were located. Soils and sediments within a given habitat type were combined as a single medium for purposes of exposure evaluations. This combined medium is hereafter referred to as "soil-sediment."
- Habitat types defined within the Coeur d'Alene River basin include riverine, palustrine, lacustrine, riparian, agricultural, and upland.
- Current chemical concentrations are present at a steady state and will not change over time.
- Chemicals not detected or analyzed are not present or evaluated. The EcoRA is focused on the metals contamination resulting from the historic mining activities
- Future land use will be similar to current use. Special-status species are present and are considered to be potential receptors ~~of the most concern~~ for current and future land uses. or
- The exposure point concentration for each chemical is as bioavailable as the chemical upon which the toxicity information is based.
- Toxicological information that has been used represents information currently available from literature and database searches, as well as the results of site-specific studies and bioassay tests.
- Exposure to fish occurs through ingestion and direct contact with surface water.

- Exposure to aquatic plants and benthic invertebrates occurs through ingestion and direct contact with soil-sediment or surface water.
- Exposure to amphibians occurs though direct contact with surface water.
- Exposure to terrestrial plants occurs through root uptake from soil-sediment.
- Exposure to terrestrial invertebrates occurs through ingestion and direct contact with soil-sediment. Exposure to microbial processes occurs through direct contact with soil-sediment.
- Exposure to birds and mammals occurs through ingestion of soil-sediment, surface water, and food (including potential bioaccumulation). Dermal and inhalation exposures were not quantitatively addressed because they are considered relatively minor exposure pathways in relation to direct uptake and/or bioaccumulation through the food chain.

1.4 APPROACH

The Coeur d'Alene River basin has received an intensive level of study over many years. Information generated from these studies forms the basis of this EcoRA. The EcoRA was performed in general accordance with the following guidance documents and work plans:

- *Ecological Assessment of Hazardous Waste Sites* (USEPA 1989)
- *Draft Technical Work Plan for the Bunker Hill Basin-Wide RI/FS Panhandle Region of Idaho Including Benewah, Kootenai, and Shoshone Counties (URSG and CH2M HILL, 1998)*
- *Supplement 03: Ecological Risk Assessment to the Draft Technical Work Plan for the Bunker Hill Basin-wide RI/FS Panhandle Region of Idaho Including Benewah, Kootenai, and Shoshone Counties (URSG and CH2M HILL,1999a)*
- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessment, Interim Final* (USEPA 1997a)
- *EPA Region 10 - Supplemental Ecological Risk Assessment Guidance for Superfund* (USEPA 1997b)
- *Framework for Ecological Risk Assessment* (USEPA 1992a)
- ECO Updates, Volume 1, Numbers 1 through 5 (USEPA 1991a, 1991b, 1992b, 1992c, 1992d)
- ECO Updates, Volume 2, Numbers 1 through 4 (USEPA 1994a, 1994b, 1994c, 1994d)

- ECO Updates, Volume 3, Numbers 1 and 2 (USEPA 1996a, 1996b)
- *Final Guidelines for Ecological Risk Assessment* (USEPA 1998)

Add Oct 1999 Eco Guidance

The overall objective for the EcoRA is to define the baseline or existing risks to ecological receptors and to provide risk managers with the information needed to achieve the ecological management goals for the area and to make remedial decisions for ~~each portion of~~ the basin. The ecological management goals, as well as the ecological endpoints to evaluate them, are presented in Section 2.4 of this document. This EcoRA provides an ecological and site characterization summary including an assessment of potential ecological risks within each of the CSM units. It identifies the presence and level of the COPECs and evaluates the presence of exposure pathways to ecological receptors. If the exposure pathways are likely to be complete (that is, receptors may be exposed to COPECs), the risks to those receptors will be evaluated using a conservative screening-level approach. Where more-detailed site-specific information is available, the EcoRA evaluates risks in greater detail.

Ecological risk assessments are usually conducted in a phased approach, as recommended by the EPA (1991b and 1992c). The phased approach may involve three or more major data collection tasks or phases, during which the data and observations from one phase are used to determine whether further studies are needed to meet the objectives of the assessment.

With the phased approach, Phase 1 is used to characterize the site and contaminant levels, then to screen the available data against relevant criteria and to determine whether exposure pathways to ecological receptors exist. Phase 2 uses additional sampling to complement existing data and to evaluate actual or potential bioaccumulation in plants and animals at the site. If the results of the previous investigations indicate that ecological impairment is occurring, then Phase 3 studies would be conducted to provide critical information on actual bioaccumulation and site remediation requirements.

need to note that some data has been specifically collected for EcoRA (e.g. FS908, FS909, FS911, Bull trout work, etc.)

The approach for this EcoRA differs from the typical approach in the fact that these evaluations are based upon the results of studies conducted within the Coeur d'Alene River basin over a long period of time. The data generated from these studies were not always subjected to consistent, rigorous data validation procedures. They were, however, either published through a series of peer-reviewed scientific papers or were circulated for review and updated based on reviewer comments. The data was reviewed prior to inclusion in the database used ~~in the EcoRA~~ to ~~pet~~ calculate the risk assessment.

Information on ecological habitats and their relative quality has been assembled from previous site studies and available local and regional publications. This information, in conjunction with site visits and meetings completed during 1998 and 1999 was used to develop the preliminary ecological and site characterizations and to identify preliminary COPECs, habitats, and potential ecological receptors as summarized in the Draft Problem Formulation ~~document (USEPA 1999)~~. This information is expanded upon in this document using the frozen RI/FS chemical database; site-specific biological surveys, studies and bioassays; and screening benchmarks based on bioaccumulation models developed using regression analyses. Risks to ecological receptors will be evaluated using a weight-of-evidence approach using all data available for habitats within each CSM Unit.

better to say the RI/FS chemical database as of ____ date may largely

Because this EcoRA is based ~~entirely~~ on previously collected data from independent studies, it is likely that the data ~~will~~ not be sufficient to address risks to all receptors in all areas. If data are not adequate for risk assessment, further sampling and investigation may be required in a subsequent phase of the RI to quantify the risk of adverse effects to ecological receptors based on discussions among the risk assessors, responsible parties, and regulators. These data may include field and/or laboratory toxicity bioassays or tissue analyses.

However, if exposure pathways are not likely to be complete (for example, COPECs are not present where the ecological receptors would be exposed) that particular exposure pathway will be recommended for no further ecological investigation. On the basis of the EcoRA results, meetings will be held among the risk assessors and regulators to determine whether remediation is required, no further action is required, or further studies are required to reduce the uncertainty so that future remedial activities can be adequately determined.

1.5 ORGANIZATION

This EcoRA is organized to present the evaluations of ecological resources within the Coeur d'Alene River basin as follows:

- Section 2.0 - Problem Formulation - Describes the site background, ecological setting, and current ecological condition/status; identifies COPECs; discusses selection of ecological management goals, assessment endpoints, and measures; and describes the ecological conceptual site model for each CSM Unit.
- Section 3.0 - Analysis - Includes ~~the~~ exposure characterization and ecological effects characterization, as follows:
  - Exposure Characterization – Evaluates various sources, as well as spatial and temporal distribution of chemical, biological, and physical stressors; describes exposure assumptions and models for each exposure pathway; and presents the exposure estimates for each representative species.
  - Ecological Effects Characterization - Presents the chemical stressor-response analyses including literature-derived and site-specific single-chemical toxicity information for each COPEC, site-specific ambient media toxicity tests, and site-specific field surveys; the biological and physical stressor-response/condition analyses; and the stressor-response profiles for chemical, biological, and physical stressors.
- Section 4.0 - Risk Characterization – Presents the risk estimation and risk description for chemical, biological, and physical stressors in each CSM Unit. It also summarizes the uncertainties and limitations associated with the risk assessment data, approach, and evaluations conducted.
- Section 5.0 - Conclusions and Ecological Remedial Action Objectives - Summarizes the overall conclusions and ecological remedial action objectives from the EcoRA.

2.0 Problem Formulation

SECTION 2.0 PROBLEM FORMULATION

2.1 SITE BACKGROUND

2.1.1 Location

The Coeur d'Alene River basin originates near the Idaho-Montana border and extends westward, draining approximately 3,810 km^2 of the western slope of the Bitterroot Mountains (Beckwith et al. 1997) (Figure 2.1.1-1). The North and South Forks of the Coeur d'Alene River are rocky, high-gradient streams in narrow valleys confined by steep hillsides (Beckwith et al. 1997; Ridolfi 1998). The North and South Forks come together near Enaville to form the main stem Coeur d'Alene River. The main stem Coeur d'Alene River is a fine substrate, low-gradient meandering river in a broad valley. In this valley, 12 shallow lateral lakes and thousands of acres of wetlands are hydraulically connected with the main stem Coeur d'Alene River. The main stem Coeur d'Alene River flows into Coeur d'Alene Lake near Harrison. Coeur d'Alene Lake discharges ~~through~~ into the Spokane River, which is a tributary of the Columbia River.

A more complete description of the Coeur d'Alene River basin, including climate, geography, land use, and the regional hydrogeologic setting are provided in Section 1.4.1 of the RI report *[[Reference?]]*.

could ~~one~~ we also reference the CSM summary that Don is producing for distribution in August?

2.1.2 Site History

Mining began in the Coeur d'Alene River basin with the discovery of silver in 1884. Soon after, mines, mills, and towns began to alter the landscape of the Coeur d'Alene River basin. The Bureau of Land Management has identified approximately 1,080 mining or milling features within the Basin that are a result of mining activity within the district (BLM 1999). Over the years, improvements have been made in mining technologies, transportation, concentration techniques, and the handling of waste products from mining activities, all of which have affected the Coeur d'Alene River basin and its inhabitants. From excavation of the district's first mines in the late 1800s to the present, the Coeur d'Alene mining district has been one of the leading producers of lead, zinc, and silver ore in the United States. Gold, antimony, tungsten, and copper have also been mined in the Coeur d'Alene basin.

Much of the ore produced in the basin required concentration before smelting. The first mill in the basin, associated with the Bunker Hill mine, began operations in 1886 (Casner 1991). Between 1886 and 1997, at least 44 mills are known to have operated in the South Fork Coeur d'Alene River basin. Initially, ores were concentrated by pulverization and gravity separation. Pulverized material was mixed with water and agitated or "jigged." This separated the heavier ores from the lighter host rock. The valuable ores were collected as concentrates, and the waste material, or jig tailings, was sluiced to dumps or to nearby flowing surface water. Gravity separation was an inefficient recovery process, and jig tailings contained as much as 10% lead or zinc (Long 1998).

Xtc in
Some of USGS results

In 1912, flotation milling was introduced to the basin (Casner 1991). Flotation milling involved finer pulverization of ores and mixing with water and an oil or grease flotation material. When the mixture was agitated and aerated, metal sulfides adhered to the froth on top and were drawn off as concentrates. The host material settled and was sluiced as tailings to dumps or to nearby flowing surface water. Flotation milling ~~greatly~~ enhanced the efficiency of recovery of minerals, so the remaining tailings had lower *concentrations* of valuable *minerals* than did jig tailings. why in italics?

The waste material from the mills contained sulfide and oxide compounds of antimony, bismuth, cadmium, copper, gold, lead, iron, silver, and zinc. The oxide and sulfide forms (when weathered) are leachable and subject to mobilization (MPG 1992a).

Mills were constructed near sources of surface water, because milling required large volumes of water. Many of the mills were located in steep narrow canyons with little area available for tailings disposal, so tailings were discharged to the streams or sluiced to the South Fork Coeur d'Alene River (Fahey 1990). Mills along the South Fork Coeur d'Alene River discharged most processing wastes directly to the river. Tailings dumped in the floodplain often subsequently eroded to the stream (Casner 1991). For over 80 years, from 1886 (when milling began in the basin) until 1968, when mills were required to impound tailings, the predominant tailings disposal method upstream of Elizabeth Park was discharge to nearby streams (Fahey 1990; Long 1998). Downstream of Elizabeth Park, tailings were deposited in the current locations of the Central Impoundment Area (CIA) and Page Pond beginning in 1926 (MFG 1992a).

Tailings have been mixed with alluvium and redistributed throughout the Coeur d'Alene River basin (MFG 1992a). Jig tailings, which were sand-sized particles, settled rapidly on the banks of the creeks in which they were deposited. Seasonal high flows flushed the jig tailings downstream. Flotation tailings, ~~called~~ slimes because of their fine silty texture, traveled much farther downstream than jig tailings. ~~Jig and flotation tailings were transported downstream~~ and deposited on the floodplains, banks, and beds of the South Fork and lower Coeur d'Alene rivers (MFG 1992a). In 1903, the first of a series of pollution damage suits was filed by a Shoshone County farmer (Casner 1991). By the mid-1920s, a visible tailings plume had extended the length of the Coeur d'Alene River, across Coeur d'Alene Lake, and as far as the Spokane River (Casner 1991). can't say that flotation tailings traveled farther downstream

During the 1940's, some jig tailings deposits in the basin were re-mined, mainly for their high zinc content. This resulted in the production of additional flotation tailings from that process, but those tailings contained less zinc.

In the late 1960's impoundment of tailings became the standard practice and subsequent releases to streams have been limited mainly to lateral erosion of historic tailings piles and redistribution of tailings released previously. Tailings impoundments continue to release metals-contaminated water to surface water and groundwater, but in response to requirements of the Clean Water Act, releases to surface waters from permitted impoundments have been greatly reduced over time.

Additional information on site history id provided in Section 1.2.2 of the RI report ***[[Reference?]].*** is say mining company

studies not opposition studies

2.1.3 Previous Ecological Investigations

Effects of metals contamination on biota in the Coeur d'Alene River basin have been studied at least since the 1930's (Ellis, 1940). Because of changes in waste management practices that have affected ongoing releases of metals, the more recent assessments are most relevant to this risk assessment. ~~In particular,~~ studies done in support of a natural resources damages assessment (NRDA); opposition studies related to that assessment; studies done by the State of Idaho as part of its beneficial uses reconnaissance program (BURP); evaluations of particular mine sites or stream systems by the U.S. Bureau of Land Management; U.S. Bureau of Mines, and U.S. Forest Service, several university theses and dissertations; and studies done to develop a basis for site-specific water-quality standards for part of the basin have been used in this risk assessment as sources of information as cited in the sections that follow.

EPA tox investigations

2.2 ECOLOGICAL SETTING

2.2.1 Identification of CSM Units

- See comments on Figures - see if Kathy Carpenter has better maps

The conceptual site model (CSM) Units (Figures 2.2.1-1 through ~~2.2.1~~-3) have a fairly large geographic scale, but are sufficiently homogeneous ~~that~~ types of waste sources, mechanisms of release and transport of waste, and the natural resources affected by the release of wastes are similar throughout each CSM Unit. The CSM Units were numbered from upstream to downstream (one through five). Each of the CSM Units was further divided into smaller components. For CSM Unit 1, which includes most of the larger, upper tributaries in the Coeur d'Alene River basin, individual watersheds (e.g., Canyon Creek, Ninemile Creek) were selected as an intermediate subdivision because risk assessments and ongoing and future remedial actions could be done at a watershed scale.

The watersheds in each of the CSM Units were further divided into segments based ~~on more~~ detailed ~~geo-~~morphology and other characteristics. Table 2.2.1-1 lists the segments within each CSM ~~Unit~~, and the geographic boundaries of the segments are shown on Figures 2.2.1-1, 2.2.1-2, and 2.2.1-4. The CSM watersheds are also listed, but for CSM Units 2 through 5 the watersheds are named only because the data base used to contain the data assembled for the CSM required an entry in that column; for aquatic receptors there is no analysis at the watershed level for CSM Units 2 through 5. More detailed analysis has been done at the CSM segment level, discussed below for the individual CSM Units.

no 2.2.1-4

?

2.2.2 Identification of Habitats and Potential Ecological Receptors

In this section, we identify and describe the habitats that could potentially be affected by releases of mining-related hazardous substances in each CSM unit. Plant and animal species potentially associated with the habitats are also described.

CSM Units 1, 2, 3, and 4 lie within the Northern Rocky Mountains ecoregion, which is characterized by rugged, high mountains with sharply crested ridges dissected by steep-walled, narrow stream valleys (Omernick and Gallant 1986). The hydrology of the region is snowmelt-dominated with occasional rain or snow events. Much of CSM Unit 5 lies along the border of the Northern Rocky Mountains and Columbia Basin ecoregions. The Columbia Basin ecoregion is characterized by deep, dry channels cut into the underlying Columbia River basalt formation. The arid landscape is composed of irregular plains, tablelands with high relief, and low mountains. The habitats within the CSM units that will be evaluated in this risk assessment are shown in Table 2.2.2-1. The following subsections describe habitat features and representative species found in relatively undisturbed examples of each habitat type.

2.2.2.1 Riverine Habitat

2.2.2.1.1 CSM Units 1 and 2. The riverine habitat of CSM Units 1 and 2 includes the higher and midgradient segments of the South Fork Coeur d'Alene River and its tributaries, and a midgradient segment of the North Fork Coeur d'Alene River and its mid- to high-gradient tributaries, Beaver and Prichard Creeks. Stream segments of interest in CSM Unit 1 are predominantly low-order stream channels contained within V-shaped canyons and having high gradients. They tend to have low sinuosity and predominantly gravel to boulder type substrate. Natural aquatic habitat features include riffles, runs, and drops with little slow water aside from pocket water provided by boulders. Figure 2.2.2.1-1 shows relatively high quality riverine and riparian habitat for CSM Unit 1. Low-order streams in CSM Unit 1 include the South Fork Coeur d'Alene River upstream of Wallace, and Canyon, Ninemile, Moon, Placer, Lake, and upper Pine Creeks.

Figure does not reproduce well - delete

High-gradient coldwater communities of the type found in CSM Unit 1 are characterized by native westslope cutthroat (*Oncorhynchus clarkii lewisii*) and bull trout (*Salvelinus confluentus*), sculpin (*Cottus* spp.), possibly mountain whitefish (*Prosopium williamsoni*), and introduced rainbow (*O. mykiss*), brook (*S. fontinalis*), and brown trout (*Salmo trutta*). The bull trout, considered to be at high risk of extinction in the Coeur d'Alene watershed, has been listed under the federal Endangered Species Act (Cross and Everest 1995). Benthic macroinvertebrate communities include craneflies (Tipulidae), stoneflies (Plecoptera), mayflies (Ephemeroptera), caddisflies (Trichoptera), and midges (Chironomidae). Periphyton and zooplankton are also present (Hagler Bailly 1998; R2 Resources 1996; Stratus 1999a). Wildlife that typically use the high-gradient stream habitats include Idaho giant salamander (*Dicamptodon aterrimus*), spotted sandpiper (*Actitis macularia*), American dipper (*Cinclus mexicanus*), water shrew (*Sorex palustris*), raccoon (*Procyon lotor*), and mink (*Mustela vison*) (CH2M HILL 1998 and 2000).

cite the listing

Stream segments in CSM Unit 2 are predominantly higher-order stream channels. Such channels are erosional but are contained within broader U-shaped valleys with moderate channel gradients and higher sinuosity than lower-order channels found in CSM Unit 1. These segments are coldwater, fast-flowing, and shallow, with gravel to boulder substrates. Pool frequency increases, as does the occurrence of point bars, side channels, and other important habitat features, supporting a broader diversity of fish populations. Figure 2.2.2.1-2 shows relatively high quality riverine and riparian habitat for CSM Unit 2. Moderate-gradient streams in CSM Unit 2 include the South Fork Coeur d'Alene River below Ninemile Creek, the North Fork Coeur d'Alene River from Prichard Creek to its confluence with the South Fork Coeur d'Alene River at Enaville, and the upper 5-mile section of the main stem Coeur d'Alene River from the confluence of the North and South Forks of the Coeur d'Alene River downstream to Cataldo. The main stem Coeur

figure comment ditto

d'Alene River above Cataldo has a moderate-gradient channel morphology with braids, tight meanders, several islands and side channels, riffles, and a floodplain as much as 1,000 feet wide. This section is a transition zone where the channel slope decreases from the midgradient (24 feet/mile) lower South Fork Coeur d'Alene River and North Fork Coeur d'Alene River to the low gradient (1 foot/mile) morphology of the downstream portions of the main stem Coeur d'Alene River. Fish and invertebrate species found in these moderate-gradient streams include those species found in lower-order streams plus suckers (*Catostomus* spp.), squawfish (*Ptychocheilus* spp.), and dace (*Rhinichthys* spp.) (Hagler Bailly 1998). Wildlife that typically use the moderate-gradient streams of CSM Unit 2 include many of the same species found in CSM Unit 1 plus others such as the common merganser (*Mergus merganser*), osprey (*Pandion haliaetus*), tree swallow (*Tachycineta bicolor*), and white-tailed deer (*Odocoileus virginianus*) (CH2M HILL 1998 and 2000).

2.2.2.1.2 CSM Unit 3. The lower portion of the main stem Coeur d'Alene River and 12 associated lateral lakes extend for 31 miles between Cataldo to the mouth of the Coeur d'Alene River near Harrison. Hydrologically, the lower Coeur d'Alene River can be divided into two sections that correspond to different river channel hydraulics. The first section (from Cataldo to Rose Lake) is a free-flowing river while the second section (from Rose Lake to the mouth of the Coeur d'Alene River) is characterized by the backwater conditions created by Post Falls dam on the Spokane River. The completion of Post Falls dam in 1906 resulted in an increase in the water level elevation of Coeur d'Alene Lake, in turn increasing water depths in this section of the lower Coeur d'Alene River, further reducing current velocity and sediment transport capacity.

The lower Coeur d'Alene River is characterized by a low-gradient channel morphology with an extensive floodplain bordered by steep hillsides. Figure 2.2.2.1-3 shows typical riverine and riparian (bank) habitat for CSM unit 3. The floodplain area ranges in width from 0.5 mile to as much as 3 miles at its widest point near Rose Lake. Due to the wider floodplain and lower current velocity, many suspended solids (including mine tailings) do not remain in suspension, and are deposited in the channel bed and on the floodplain in overbank flow events. In spite of these influences, there have been no large-scale changes in the pattern of the lower river channel (R2 Resources undated). The lower main stem has a wide, meandering channel and has formed deltas at its mouth in Coeur d'Alene Lake and at the entrances to some of the lateral lakes.

In 1932, prior to cessation of active tailings disposal in the river, no live fish were found over the entire length of what is now termed CSM Unit 3 (R2 Resources undated). Fishery resources have improved in the lower Coeur d'Alene since these activities were halted in 1968 (Casner 1991; R2 Resources undated), and several cold- and warm-water native species of fish (westslope cutthroat trout and northern squawfish [*Ptychocheilus oregonensis*]) can now be found in riverine, palustrine, and lacustrine habitats. A variety of salmonids (chinook salmon [*Oncorhynchus tshawytscha*] and kokanne salmon [*Oncorhynchus nerka*]) and warm-water fish (bluegill [*Lepomis macrochirus*], northern pike [*Esox lucius*], and smallmouth bass [*Micropteras dolomieiui*]) species have been intentionally introduced to the lower Coeur d'Alene River, altering the composition of the fish populations. Some evidence exists that in recent years springtime cutthroat trout migrations through the lower Coeur d'Alene River have resumed (R2 Resources undated).

P. 2.6, Sect 2.2.2.1.3 says Post Falls Dam
drains an area 3700 mi 2 but P. 2-5 says
CDA Lake drains an area 3980 mi 2
upstream area can't be larger than
downstream area

Few recent studies exist that describe the benthic macroinvertebrate fauna of the main stem Coeur d'Alene River. Hoiland et al. (1994) observed that some recovery in benthic macroinvertebrate numbers has taken place on the main stem Coeur d'Alene River at Cataldo since the early 1980s, but biotic indices were still reduced below those observed at reference stream conditions. The taxa currently present at Cataldo include chironomids (midges) and pollution-tolerant species of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). Skille et al. (1983, as cited in Falter [1999]) have performed the most recent evaluation of benthic macroinvertebrates in the 6 miles of the main stem Coeur d'Alene River immediately upstream of its confluence with Coeur d'Alene Lake, and noted that benthic macroinvertebrate abundance in this reach of river averaged 24 organisms/square meter, compared to a benthic macroinvertebrate abundance of 1,167 organisms/square meter in the lower St. Joe River, the reference stream for the study. No recent comprehensive surveys of benthic macroinvertebrate community composition have been performed in the lateral lakes of the main stem Coeur d'Alene River. Falter (1999) describes the presence of benthic crustaceans including filter feeders, grazers, shredders and predators, as well as oligochaetes (worms), clams, snails, and insects in the shallower, heavily vegetated portions of the lateral lakes and associated wetlands, with filter-feeding clams, worms, and chironomids present in sediments found in the deeper portions of the lateral lakes. Falter (1999) does not provide specific details regarding the abundance and species composition of the benthic fauna present in the lateral lakes.

Wildlife associated with the riverine habitat of CSM Unit 3 include many of the same species that occur in CSM Units 1 and 2 and others that forage along larger water bodies such as the bald eagle (*Haliaeetus leucocephalus*), a threatened species (see Section 2.2.2.7); river otter (*Lontra canadensis*); and little brown myotis (*Myotis lucifugus*) (CH2M HILL 1998 and 2000).

2.2.2.1.3 CSM Unit 5. This Unit is made up of the Spokane River and runs from the north end of Coeur d'Alene Lake in Kootenai County, Idaho, to the Columbia River at Ft. Spokane, Washington. The Spokane River has several free-flowing reaches, but the hydrology is heavily modified by a series of dams. Figure 2.2.2.1-4 shows typical riverine and riparian habitat for CSM Unit 5. The largest community within CSM Unit 5 is Spokane, and the Spokane River provides recreation to residents of the region. At Post Falls dam the river drains approximately 3,700 square miles (Bennett and Underwood 1988). The mean annual discharge of the Spokane River at Post Falls dam from 1953 to 1968 was 196 cubic meters per second (m^3/s). The record high flow (exceeding 1,416 m^3/s) was recorded in 1974 and the record low flow (2.5 m^3/s) was recorded in 1967.

Why so much attention to Post Falls Dam

Bennett and Underwood (1988) conducted a fish survey in 1985 and 1986 of a 6.25-mile section of the Spokane River from Post Falls to the Idaho-Washington state line. Several river reaches of the main stem Spokane River had suitable rainbow trout spawning habitat, defined as gravel between 10 and 76 mm. Tributaries to this section of the Spokane River (Skalan Creek and an unnamed tributary) did not provide suitable spawning habitat. Flow regimes varied greatly during the study period because of the washout of the City of Spokane's Upriver dam. During low flows, some spawning sites were exposed. The quantity of available fry habitat also decreased with decreasing flows. Fifteen species of fish were sampled in the study area. Rainbow trout was the most abundant fish species, and suckers (*Catostomus* spp.), speckled dace (*Rhinichthys osculus*), and yellow perch (*Perca flavescens*) were also abundant. This section of the Spokane River provides a moderately productive and locally popular rainbow trout fishery. However, annual mortality is high and few fish reach a 50-cm size class. Fluctuation in water flow was found to affect the trout population. Johnson (1997) also found suitable spawning habitat during a 1995 through 1996 survey of an 18-mile section of the Spokane River from Post Falls dam to the Upriver dam pool. He concluded that rainbow spawning success in the upper Spokane River appears to be strongly dependent upon fish initiating spawning early in the season (beginning of April) to ensure adequate time for fry development and emergence prior to stream flow decline.

Kleist (1987) evaluated the fisheries potential of a 15.9-mile portion of the lower Spokane River from the Monroe Street dam in Spokane to Nine Mile Falls dam. The upper 10.1-mile portion of the study area is characterized by sequences of riffles, runs, and pools, characteristic of a free-flowing system. The lower 5.8-mile portion of the study area is slack water impounded by Nine Mile Falls dam. Substrate in the uppermost end of the impoundment consists mostly of boulders, and downstream it is mostly silts, loams, and sands. The upper portion provides many of the habitat characteristics required by trout (e.g., clear, cold water and a silt-free, rocky substrate in riffle-run areas). However, aspects of vegetated stream banks, instream cover, water flow, and pool-to-riffle ratios appear to provide less than optimum conditions. In the upper portion of the study area, the benthic invertebrate community was dominated by the families Hydropsychidae and Baetidae (mayflies), and salmonids were the most abundant group of fish. The benthic invertebrate diversity decreased in Nine Mile Reservoir where oligocheates (worms) and chironomids (midges) dominated. Bridgelip sucker (*Catostomus columbianus*) was the most common fish sampled in Nine Mile Reservoir. Crayfish were not found in the upper portion of the study area, but were relatively abundant in Nine Mile Reservoir.

Pfeiffer (1985) conducted a general assessment of aquatic resources on the lower Spokane River reservoirs. Collectively yellow perch, northern squawfish, and largescale sucker (*Catostomus macrocheilus*) were the most abundant fish caught in gill nets on the lower Spokane River reservoirs. The most abundant benthic invertebrates surveyed were midges, worms, and mayflies.

The wildlife species that utilize the riverine habitat in CSM Unit 5 are similar to those that utilize the riverine habitat in CSM Units 2 and 3.

2.2.2.2 Lacustrine Habitat

2.2.2.2.1 CSM Unit 3. The 12 lateral lakes associated with the lower Coeur d'Alene River range in size between 85 and 640 acres, with thousands of acres of associated wetlands (Figure 2.2.2.2-1). They are generally shallow, with mean depths of 5 to 10 feet, but the maximum depth ranges to 50 feet. The lateral lakes are eutrophic, with both a high chlorophyll content in the water column and extensive growths of aquatic rooted plants. These include water lilies (*Nuphar* spp.), elodea, bladderwort (*Utricularia* spp.) and various pondweeds (*Potamogeton* spp.).

The Idaho Department of Fish and Game actively manages a warmwater fishery in several of the lateral lakes. The warmwater fish and several of the coldwater fish species are non-native species whose introductions have substantially altered the trophic dynamics of the lakes. Summertime don't we know whether water [illegible] can support

water temperatures in the lateral lakes may be too warm to support a coldwater salmonid fishery. Northern pike growth rates in the lateral lakes are high due in part to the abundance and diversity of prey (Stratus 1999b).

The lateral lakes provide areas for waterfowl nesting, feeding, and other activities. Twenty-five species of waterfowl have been identified in the vicinity of the lateral lakes during spring and fall migrations. More than 280 bird species are found throughout the Coeur d'Alene basin, many of which utilize lacustrine and palustrine habitats. Representative birds include black tern (*Chlidonias niger*), a species of concern in Idaho (see Section 2.2.2.7); Canada goose (*Branta canadensis*); mallard; common goldeneye (*Bucephala clangula*); osprey; and tree swallow (CH2M HILL 1998 and 2000). Lacustrine and palustrine habitats also support numerous other wildlife species, including beaver, mink, muskrat (*Ondatra zibethicus*), river otter (*Lontra canadensis*), and raccoon. Several frog and salamander species are also present.

2.2.2.2.2 CSM Unit 4. Coeur d'Alene Lake is a natural lake occupying a naturally dammed river valley with a drainage area of approximately 3,980 square miles. Additional lake surface elevation control is provided by the Post Falls dam. At its normal full pool elevation of 2,128 feet above msl, the lake occupies nearly 50 square miles. The average depth of Coeur d'Alene Lake is 72 feet, while its maximum depth is 209 feet. The lake is roughly 2 miles wide by 24 miles long with a shoreline of 133 miles. Land use activities within the watershed of Coeur d'Alene Lake include forestry, mining and ore processing, agriculture, recreation, and urban development. The lake is heavily used for recreational boating, fishing, and swimming, and is the most heavily used recreational waterway in northern Idaho.

The Coeur d'Alene and St. Joe rivers supply 94 percent of the surface water inflow to Coeur d'Alene Lake. Post Falls dam ~~on~~ the Spokane River, the only surface outlet, controls the outflow of water from the lake. The residence time of water within the lake varies from year to year depending on the inflow. In 1991, hydraulic residence time was 0.45 year; in 1992, residence time was 0.89 year. The St. Joe River is the largest source of phosphorus, the limiting nutrient, in the ecosystem. Development within the basin has reverted to its original oligotrophic character following an earlier period of eutrophication caused by past discharges of untreated waste into the Coeur d'Alene and St. Joe Rivers.

[illegible]?

Native fish species historically abundant in Coeur d'Alene Lake included cutthroat trout, bull trout, mountain whitefish, peamouth (*Mylocheilus caurinus*), northern squawfish, suckers, and sculpins. Kokanee salmon were introduced to the lake in 1937. Other introduced species include chinook salmon, rainbow trout, brook trout, northern pike, tiger muskie (*Esox lucius* x *Esox masquinongy* hybrid), yellow perch, tench (*Tinca tinca*), black bullhead (*Ameiurus melas*), pumpkinseed (*Lepomis gibbosus*), largemouth bass (*Micropterus salmoides*), smallmouth bass, and white crappie. These introductions have altered the trophic dynamics of the lake.

Although as many as 62 taxa of benthic macroinvertebrates have been identified from the lake, the benthic macroinvertebrate fauna is dominated by chironomid (midge) larvae and oligochaetes (worms), with chironomids being the numerically dominant taxa. Winner (1972) noted that many of the benthic macroinvertebrate species from the southern portion of the lake were indicative of nutrient-rich waters, while the macroinvertebrates in the northern portion of the lake were indicative of more oligotrophic waters. Ruud (1996) found the benthic invertebrate communities in Coeur d'Alene Lake varied with depth and locations. Representative birds and mammals that use the lacustrine habitat of Coeur d'Alene Lake are similar to those found in the lacustrine habitat in CSM Unit 3 (CH2M HILL 1998 and 2000).

2.2.2.2.5 CSM Unit 5. Lacustrine habitat occurs within CSM Unit 5 as impoundments behind the many dams located on the Spokane River. The description of the riverine habitat for CSM Unit 5 (Section 2.2.2.1.3) includes the physical and biological characteristics of the lacustrine habitats found along the Spokane River.

Expand discussion to identify the dams and lakes.

2.2.2.3 Palustrine Habitat

2.2.2.3.1 CSM Units 1 and 2. A National Wetlands Inventory (NWI) map prepared by the U.S. Fish and Wildlife Service (provided to URSG by the Coeur d'Alene Tribe on March 27, 2000) covers the portion of the Coeur d'Alene watershed located in CSM Units 1, 2, and 3. The steep, incised canyons and relatively high-gradient nature of many of the streams in CSM Unit 1 limit the potential formation of palustrine (shallow marsh) habitat. The only palustrine habitat identified on the NWI map in CSM Unit 1 was in small isolated pockets located on the lower reaches of Pine Creek and Big Creek.

Within CSM Unit 2, the NWI map identified relatively extensive palustrine habitat on the North Fork Coeur d'Alene River downstream of Prichard, along much of Bear Creek, and main stem Coeur d'Alene River from the confluence of the North and South Forks of the Coeur d'Alene River downstream to Cataldo. Less extensive palustrine habitat was located along the South Fork Coeur d'Alene River from Kellogg downstream to the confluence with the North Fork. In addition, several isolated pockets of palustrine habitat are located on the South Fork near Osburn.

One of the largest expanses of palustrine habitat in CSM Units 1 and 2 is found adjacent to the Page Pond wastewater treatment plant sewage ponds located between Smelterville and Pinehurst. The East and West Page Pond wetlands contain three habitat types: seasonally flooded emergent, semi-permanently flooded emergent, and seasonally flooded shrub (Mullins and Burch 1993). The wetlands have been the subject of several investigations to determine the amount of contaminants present in biota. Plants sampled at the site in 1992 include sedge (*Carex* spp.), spike rush (*Eleocharis palustris*), cattail (*Typha latifolia*), thin-leaf alder (*Alnus incana*), and water birch (*Betula occidentalis*) (Mullins and Burch 1993). Cattail and duckweed were sampled in 1994 and 1995 (Burch et al. 1996). Although these plants were selected because of their food value for wildlife, they are probably indicative of the dominant vegetation found at the site. Aquatic insects sampled in 1992 included larvae damselflies and dragonflies (Mullins and Burch 1993). Tadpoles were opportunistically sampled from the East Page Pond wetland in 1992. Fish observed in the wetlands during the 1994 and 1995 study (Burch et al. 1996) included brown bullhead (*Ameiurus nebulsus*), largemouth bass, and pumpkinseed. The wetlands are a popular foraging and nesting site for waterfowl and the most commonly observed species were mallard, redhead (*Aythya americana*), ring-necked duck (*Aythya collaris*), and green-winged teal (*Anas crecca*) (Burch et al. 1996). Mammals observed at the site include moose (*Alces alces*), mule deer (*Odocoileus hemionus*), muskrat, and beaver.

2.2.2.3.2 CSM Unit 3. The NWI map and USGS digital map of geology and wetlands of the Coeur d'Alene River valley (USGS 1999) identify extensive areas of palustrine habitat within the Coeur d'Alene River floodplain in CSM Unit 3 (Figure 2.2.2.2-1). Common emergent aquatic rooted plants include sedges (*Carex* spp.), common reed, water potato (*Sagittaria latifolia*), cattail, horsetail (*Equisetum* spp.), bur-reed (*Sparganium* spp.), bulrush (*Scirpus* spp.), and cranberries (*Oxycoccus* spp.) (Stratus 1999b). Within the lower Coeur d'Alene River, palustrine habitats contain waters less than 2 meters in depth, and are characterized by aquatic, scrub-shrub, or emergent plants.

The palustrine habitat is heavily used by waterfowl for foraging and nesting. Waterfowl are most abundant during spring migration and representative species include Canada goose, mallard, tundra swan (*Cygnus columbianus*), and American coot (*Fulica americana*). Peak 1-day counts for various species between 1994 and 1997 include 3,758 tundra swans, 13,230 Canada geese and 1,730 mallards (Stratus 1999b). Many other species of birds use the palustrine habitat, including the great blue heron (*Ardea herodias*), northern harrier (*Circus cyaneus*), and black tern. Neotropical migrants also use the palustrine habitats. Representative mammals that inhabit the wetlands include beaver, raccoon, muskrat, and coyote (*Canis latrans*) (CH2M HILL 1998 and 2000).

2.2.2.3.3 CSM Unit 4. The palustrine portions of Lake Coeur d'Alene have attributes and functions similar to those of the palustrine habitat in CSM Unit 3. The numerous wetland and nearshore areas around the margins of the lake support an abundance of plants and animals, including shorebirds and waterfowl. Waterfowl are abundant throughout the year, with large numbers seasonally passing through the area. Songbirds and raptors are also abundant. Among the mammalian species present are otter, beaver, and muskrat.

any mapping or reports to be cited?

2.2.2.3.4 CSM Unit 5. Isolated pockets of palustrine habitat undoubtedly occur along the Spokane River in CSM Unit 5. However, no information was available at the time this report was prepared that systematically described these wetlands. It is assumed that the flora and fauna of the palustrine habitat in CSM Unit 5 are similar to those found in CSM Units 3 and 4.

2.2.2.4 Riparian Habitat

Riparian resources include floodplain soils and sediment, riparian vegetation, and wildlife habitat (Stratus 1999b). These resources, together with geologic, surface water, and groundwater resources, and the wildlife dependent upon the riparian zone, compose the riparian ecosystem.

The riparian zone is the transitional area between the aquatic riverine environment and the terrestrial upland environment. Riparian zones are among the most biologically, chemically, and physically diverse, dynamic, and complex terrestrial ecosystems (Naiman and Decamps 1997; Naiman et al. 1993; Hedin et al. 1997; Lyon and Sagers 1998). The riparian zone regulates the flow of energy and material between the terrestrial and aquatic environments, and between upstream and downstream reaches of a stream (Naiman et al. 1993; Naiman and Decamps 1997). Riparian zones support rich assemblages of plant and animal species (Mosconi and Hutto 1982; Hansen et al. 1998; Decamps 1993; Naiman et al. 1993; Moseley and Bursik 1994; Lyon and Sagers 1998). Natural riparian zones buffer erosive stream energy, store flood waters and reduce peak flows, and they sequester and reduce bioavailable concentrations of pollutants (Karr and Schlosser 1978; Naiman and Decamps 1997). These characteristics of riparian ecosystems are similar worldwide (Decamps 1993).

CSM Units 1 and 2

2.2.2.4.1 CSM Units 1 and 2. CSM Unit 1 includes the South Fork Coeur d'Alene River upstream of Wallace, tributaries to the South Fork, and Prichard and Beaver Creeks that feed into the North Fork Coeur d'Alene River. These reaches have high gradients, are largely incised, and are channelized in places, either naturally or by roads, railroads, and mining-related disturbances. The riparian zone occurs in the narrow floodplain on the floor of the canyons (Figure 2.2.2.1-1).

CSM Unit 2 includes the South Fork below Ninemile Creek, the North Fork from Prichard Creek to its confluence with the South Fork at Enaville, and the upper 5-mile section of main stem Coeur d'Alene River from the confluence of the North and South Forks at Enaville downstream to Cataldo.

Rivers in CSM Unit 2 flow through a broader U-shaped canyon (Figure 2.2.2.1-2). Stream and valley gradients in these areas decrease relative to gradients upstream, and the valley bottom and floodplain widen, although topographic features impose localized channel constrictions. Near Osburn and from Kellogg to Smelterville, the canyon widens further. Within these reaches, the gradient is lower and the floodplain is substantially wider. These areas are modified by transportation, industrial, urban, and residential land uses. The lower North Fork Coeur d'Alene River and lower Little North Fork Coeur d'Alene River, Canyon Creek in the Woodland Park area, and lower Pine Creek also open to U-shaped canyons.

Plant species most commonly found in riparian reference sites for CSM Units 1 and 2 (Upper Fork Ninemile Creek, upper Canyon Creek, and the Little North Fork Coeur d'Alene River) during the natural resources injury assessment (Hagler Bailly 1995) were reed canary grass (*Phalaris arundinacea*), cow-parsnip (*Heracleum lanatum*), stream violet (*Viola glabella*), ninebark (*Physocarpus malvaceus*), alder (*Alnus incana*), snowberry (*Symphoricarpus albus*), black cottonwood (*Populus trichocarpa*), grand fir (*Abies grandis*), and Rocky Mountain maple (*Acer glabrum*). Animals typical of the riparian zone in CSM Units 1 and 2 include the Idaho giant salamander; wild turkey (*Meleagris gallopavo*); song sparrow (*Melospiza melodia*); long-legged myotis (*Myotis volans*), a species of special concern (see Section 2.2.2.7); raccoon; mink (*Mustela vison*); beaver (*Castor canadensis*); deer mouse (*Peromyscus maniculatus*); and white-tailed deer (CH2M HILL 1998 and 2000).

identifies plants in ref. areas but no mention of plants in impacted areas

CSM Unit 3

2.2.2.4.2 CSM Unit 3. There is considerable overlap between the riparian and palustrine habitats within CSM Unit 3.

In this risk assessment, the riparian habitat is defined as occurring within the floodplain of the creeks and rivers. In CSM Unit 3, much of the floodplain is classified as palustrine habitat (Bookstrom et al. 1999). In fact, many of the riparian vegetation sampling sites in CSM Unit 3 that were sampled as part of the riparian resources injury assessment (Stratus 1999b) can also be classified as wetland habitat.

Downstream of Enaville and the confluence of the South and North Forks, the Coeur d'Alene River is a meandering, low-gradient, deep river. The valley opens into a broad alluvial basin, with the floodplain width exceeding 1 mile in places. The river is bordered by 12 lateral lakes ranging in size from less than 85 acres to over 600 acres (Ridolfi 1993). Thousands of acres of wetlands are associated with the lateral lakes. Riparian habitat borders the rivers, lakes, and wetlands of CSM Unit 3 (Figure 2.2.2.2-1).

Plant species most commonly found in the riparian areas of CSM Unit 3 during the natural resource injury assessment studies (Hagler Bailly 1995) were the bulrush (*Scirpus cyperinus*), reed canary grass, creeping bentgrass (*Agrostis stolonifera*), hardhack (*Spiraea douglasii*) and marsh cinquefoil (*Potentilla palustris*). Common reed (*Phragmites communis*) was recently introduced to revegetate the dredged material piles near Cataldo. This invasive non-native has spread downstream from Cataldo. Trees ~~were~~ uncommon in the CSM Unit 3 riparian areas. Animals typical of riparian areas in CSM Unit 3 are similar to those found in CSM Units 1 and 2 (CH2M HILL 1998 and 2000). are

more

2.2.2.4.3 CSM Unit 5. As described in Section 2.2.2.1, much of the Spokane River runs through a narrow, steep gorge cut through basalt. A narrow band of riparian vegetation borders the river for most of its length (Figure 2.2.2.1-4). Willows, grasses, and shrubs constitute most of the riparian vegetation occurring along a 16-mile section of the Spokane River extending from the Monroe Street dam in Spokane to Nine Mile Falls dam (Kleist 1987). The upper 10 miles of the study area have sparse riparian vegetation that occurs at or near the high water mark. The absence of riparian vegetation in the upper area was attributed to the dynamics of floodplain transitions created by the river or the steep and/or rocky terrain through which the river flows. The lower 6 miles, which form Nine Mile Reservoir, have much significant riparian vegetation, which is often overhanging and/or in the water. Undercut banks are frequently available as cover for fish in some reaches of shoreline where deeply rooted vegetation occurs. Animals typical of the riparian zone in CSM Unit 5 are generally similar to those found in CSM Unit 3.

2.2.2.5 Upland Habitat

Upland habitat is located in CSM Units 1 and 2 downgradient from sources of mining-related hazardous substances. Slopes of valley walls are generally steep. The high points near the headwaters of the South Fork and in the upstream reaches of Canyon and Ninemile Creeks range in elevation from approximately 5,000 to 6,600 feet (Stratus 1999b). Between Wallace and Kellogg, high points adjacent to the riparian corridor are generally within the 3,000- to 4,500-foot elevation range. Gross physical factors that control the moisture and growing season length include elevation, slope, and aspect. South-facing slopes are typically warmer and drier and support more xeric shrubland and grassland communities. North-facing slopes tend to be heavily forested with conifers. Valley bottoms generally stay cooler than slopes with a southerly or westerly aspect, particularly a result of diurnal temperature fluctuation and cold air drainage down valley. Additional geographic effects may produce cold pockets that result in localized vegetation response.

Upland forest communities characteristic of north- and east-facing slopes are often dominated by western hemlock (*Tsuga heterophylla*) and western red cedar (*Thuja plicata*), with western white pine (*Pinus monticola*), western larch (*Larix occidentalis*), and lodgepole pine (*Pinus contorta*). On south- and west-facing slopes, Douglas fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), and Ponderosa pine (*Pinus ponderosa*) are typical dominants (Stratus 1999b). On the dry south-facing slopes, grasses such as redtop bentgrass (*Agrostis stolonifera*), bluebunch wheatgrass (*Agropyron spicatum*), pinegrass (*Calamogrotis rubescens*), and tufted hairgrass (*Deschampsia cespitosa*) and shrub species including ceanothus (*Ceanothus velutinus*), huckleberry (*Vaccinium membranaceum*), serviceberry (*Amelancier alnifolia*), chokecherry (*Prunus virginiana*), mountain ash (*Sorbus* spp.), ninebark, snowberry, and wild rose (*Rosa* spp.), among others, are common. Representative birds in the upland habitat include Swainson's thrush (*Catharus ustulatus*), crows (*Corvus brachyrhynchos*), ruffed grouse (*Bonasa umbellus*), wild turkey, and American kestrel (*Falco sparverius*). Mammals commonly found in uplands include the deer mouse, masked shrew (*Sorex cinereus*), chipmunk (*Tamias* spp.), red squirrel (*Tamiasciurus hudsonicus*), mule deer, and coyote (CH2M HILL 1998 and 2000).

2.2.2.6 Agricultural Habitat

Approximately 9,500 acres of agricultural land fall within the floodplain of the main stem Coeur d'Alene River in CSM Unit 3. The surface soils on many of the low stream terraces along the Coeur d'Alene River that are used for agriculture are termed slickens and are composed of mill tailings that have been deposited with the annual alluvium (Frutchey 1994). Pasture and cultivated hay fields are the dominant agricultural land uses. Redtop (*Agrostis alba*) is the primary pasture plant and other species such as reed canary grass (*Phalaris arundinacea*) are planted to a lesser degree. Oats (*Avena staiva*) and barley (*Hordeum* spp.) are the primary species used as hay. The agricultural lands may become inundated during heavy storms or high flow events.

Several wildlife species use the agricultural habitat for foraging, breeding, and/or rearing young. Representative species include the snipe (*Capella gallinago*), Canada goose, northern harrier, wild turkey (*Meleagris gallopavo*) deer mouse, coyote, and white-tailed deer (CH2M HILL 1998 and 2000).

2.2.2.7 Threatened and Endangered Species

The U.S. Fish and Wildlife Service identified federally listed and proposed endangered and threatened species, and species of concern that may occur in the Coeur d'Alene basin RI/FS area (Hallock 2000); that information is summarized in Table 2.2.2.7-1. For the purpose of the species listing, the Coeur d'Alene basin RI/FS area was defined as stream channel and adjacent riparian/floodplain areas for the North Fork Coeur d'Alene River, South Fork Coeur d'Alene River (including some upland areas), and the main stem Coeur d'Alene River, together with their tributaries, the lateral lakes, Coeur d'Alene Lake, and the Spokane River downstream to Fort Spokane.

- check this
- call Suzanne re updated list

Species identified as threatened, endangered, of special concern, or other priority management categories in the states of Washington and Idaho are identified in Tables 2.2.2.7-2 to 2.2.2.7-5. The state list of species of concern for the Coeur d'Alene project area in Idaho was provided to the Spokane office of the U.S. Fish and Wildlife Service (USFWS) by the Idaho Department of Fish and Game (IDFG), in response to a request for information pertinent to Section 7 consultation under the Endangered Species Act (ESA). This list was obtained from USFWS in February 2000, and includes all confirmed or historic sightings of state-listed species of concern in Benewah, Shoshone, and Kootenai counties. The 2000 list was correlated with the current county-by-county list of special-status species available on the Idaho Conservation Data Center Website. This list does not necessarily include the federally listed threatened and endangered species previously identified.

reference?

The list of special-status species in Washington was derived from two sources of information. The Washington Department of Fish and Wildlife (WDFW) provided information on special-status animals species in the project area of the Spokane River basin from queries of their Priority Habitats and Species Database. Information on special status plant species in the project area was provided by the Washington Department of Natural Resources from the Natural Heritage Database. The state lists in Washington include known occurrences of federally listed threatened and endangered species.

Additional species of concern identified by the Washington State Department of Ecology and the Spokane Tribe of Indians (Kadlec and Kirschner 2000) that may occur in the Coeur d'Alene basin RI/FS area include the golden eagle (*Aquila chrysaetos*), pileated woodpecker (*Dryocopus pileatus*), and Lewis' woodpecker (*Melanerpes lewis*).

• We need to make a stronger statement regarding the NRDA

2.2.3 Current Ecological Condition/Status

Ecological habitat conditions are summarized ~~by CSM~~ watershed and habitat type in this section. Habitat types include upland, agricultural, ~~riparian~~, floodplain, palustrine, lacustrine, and riverine. The discussion of habitat conditions ~~includes human~~ activities and their impacts on habitat quality. The information summarized here is from the Natural Resource Damage Assessment (NRDA).

flood plain not one of our habitats

2.2.3.1 CSM Units 1 and 2

The upland, riparian, and riverine habitats in CSM Units 1 and 2 have been impacted, to varying degrees, by human activities. Two of the largest sources of impact are the result of mining and timber harvesting. Both of these activities started in the mid to late 1800s.

Mining included the development of roads, mines, mill sites, and smelters. The mining and milling of ore created large volumes of waste rock and tailings that were dumped in and near the stream system. Much of the basin was also systematically harvested for timber (Cross and Everest 1995). Timber harvests were conducted using railroads, splash dams, and log drives. Extensive networks of forest roads developed for mining exploration and timber harvesting are present in varying densities throughout the basin. To a large extent, these activities have resulted in most streams in CSM Units 1 and 2 now being paralleled by roads.

Other activities that have impacted CSM Units 1 and 2 include agricultural practices, livestock grazing, and urbanization. The impacts of these activities on riverine habitats are well documented (Armour et al. 1991; Karr 1991; Naiman et al. 1992a 1992b).

The cumulative effect of human activity in CSM Units 1 and 2 has been to degrade the condition of the upland, riparian, and riverine habitats. The quantity and quality of available habitats has been reduced and habitat-forming and -maintaining processes destabilized (Casner 1991; Cross and Everest 1995; Hagler Bailly 1998). This in turn has affected stream channel stability and morphology, seasonal stream flow patterns, and cycling and transport of nutrients. Many sections of the streams are now channelized. Overall, sediment and bedload transport processes are unstable and there is loss of riparian vegetation. The high density of roads, along with other land use activity, has fragmented upland habitats and reduced habitat quality for native wildlife species. The current ecological condition/status of habitats in each CSM watershed of the study area is described in the following sections.

2.2.3.1.1 Upper South Fork Coeur d'Alene River. In general, this segment (UpperSFCDRSeg01) occurs above the zone of substantial impact from mining-related hazardous substances that begins at Wallace (Stratus 1999c). The eastern portion of this segment encompasses the headwaters of the South Fork Coeur d'Alene River. There has been limited mining and timbering activity in this area. Mining-related impacts to the floodplain and riparian zone are increasingly apparent moving downstream from Larson. The following paragraphs summarize impacts to habitats in the segment.

Upland Habitat. Upland habitats in the segment are not as modified as those in other segments. Mining exploration and development has not been as intense or extensive when compared to other areas of the basin such as Canyon Creek. Similarly, as shown in Table 2.2.3-1, forest road development is less extensive. Total road density is 4.0 miles per square mile, of which 3.1 miles per square mile are low-speed gravel or dirt access roads. This level of road density has been shown to be detrimental to upland wildlife species; however, many of these roads are concentrated in developed riparian and floodplain areas around Mullan, Larson, and the Lucky Friday Mining Complex.

Riparian Habitat. Historically there have been large inputs of fine- and coarse-grained material to the stream system in the western portion of the segment. In addition to mining-related impacts, the central and downstream sections of the segment have been extensively modified by highway and secondary road construction. The riparian and floodplain areas of the segment have also been modified by agricultural, residential, industrial, and urban development.

Riparian habitat conditions in the lower half of the segment are degraded; therefore, riparian-dependent wildlife species will be limited or absent in these areas. With the exception of I-90 and mining-related infrastructure, the upland areas of this segment are relatively undeveloped and road densities are low.

Riverine Habitat. Throughout this segment, the South Fork is located adjacent to I-90. Between the Lucky Friday Mining Complex and Wallace (western end of the segment), the river has been extensively channelized. As a consequence, riparian and instream habitat structure is degraded. The effects of the degradation in the channelized area are reflected in a progressive increase in stream temperatures observed during baseflow conditions in warm-weather years.

Water quality declines from the headwaters to Wallace. Above Larson, measured concentrations of cadmium, lead, and zinc in surface water rarely exceeded acute and chronic ambient water quality criteria (AWQC) except in the case of lead, where the chronic AWQC was exceeded in 9 of 17 samples (Stratus 1999a). From Larson down to Wallace, chronic lead and chronic and acute zinc AWQC were regularly exceeded.

The effects of degraded habitat and water quality on the UpperSFCDRSeg01 below Larson are reflected by some observed changes in fish populations and invertebrate communities. Based on estimates of population density observed over a 3-year period (Stratus 1999c), trout populations at sampling locations throughout this segment are comparable to those observed in reference streams and other less modified watersheds throughout the basin. The high trout density may be associated with migration of trout from refuges in the headwaters into downstream reaches. The trout species present during sampling were native cutthroat and introduced brook and rainbow trout. Densities of sculpin, a species demonstrated to be sensitive to metals contamination and habitat disturbance, are highest at the headwaters and decreased to zero near Wallace (Reiser 1999; Rahel 1999; Stratus 1999d 1999c).

Taxa richness is considered to be a measure of the condition of the aquatic macroinvertebrate community. In general, macroinvertebrate taxa richness in the watershed is comparable to that observed at reference locations on the St Regis River (IDEQ 1999; Stratus 1999a 1999c 1999d). However, taxa richness does decrease between survey locations in the headwaters (17.5 species observed) verses those above Wallace (13.3) indicating declining habitat and water quality conditions. Because the watershed is generally considered to be above the zone of substantial impact from mining-related hazardous substances, this decline is indicative of the possible influence of physical habitat conditions. The reduction in taxa richness is apparently due to the loss of the more sensitive mayfly species.

2.2.3.1.2 Canyon Creek. Habitat conditions in the Canyon Creek watershed vary considerably from the headwaters to the mouth of the system at Wallace. The headwaters, located in segments CCSeg01 and the uppermost end of CCSeg02, are relatively undisturbed with an intact and well-vegetated riparian zone, stable stream banks, and a diverse distribution of substrate types. Mining-related and other human impacts largely begin in CCSeg02 and continue to the confluence with the South Fork Coeur d'Alene River. Impacts from stressors such as channelization, road development, residential development, and releases of hazardous substances have degraded the riparian and aquatic habitats and impaired their ability to support populations of aquatic and terrestrial animals.

Upland Habitat. The upland habitats of Canyon Creek have been modified by mine exploration/development and timber harvesting. The extent of habitat modification is reflected in the high road densities present in the watershed. As shown in Table 2.2.3-1, the total road density is 4.8 miles per square mile, of which 4.1 miles per square mile are forest access or other low-speed unsurfaced roads. These road densities are above thresholds believed to be limiting to upland wildlife species.

Riparian Habitat. Canyon Creek has been extensively channelized in the central portion of the watershed to protect roads, residences, and mining-related facilities. Channelization influences begin in CCSeg02 around the town of Burke and become extreme in CCSeg04, where the stream enters an approximately ½-mile-long box culvert, and then emerges to a tightly constrained channel continuing downstream for several miles. There has been extensive modification of the riparian zone and floodplain in the lower reaches of CCSeg04 and CCSeg05 in conjunction with historical mining-related impacts; development of residential, industrial, and transportation infrastructure; recovery of mine tailings; and ongoing remediation activities. Remediation activities have attempted rehabilitation of channel habitat structure. In general, the condition of riparian habitat, in-stream habitat structure, and the stability of the channel substrate decrease from the headwaters downstream to the mouth at Wallace.

The riparian vegetation in the lower half of the watershed has been significantly degraded. Little or no riparian vegetation is present throughout much of CCSeg04 and CCSeg05 due to development, the impacts of mining-related hazardous substances, and the removal of much of the surface soil during recovery of tailings deposits for reprocessing. Given the degraded state of the riparian habitat, riparian-dependent wildlife species will be limited or absent in these areas.

Riverine Habitat. Habitat conditions for fish, aquatic, and riparian wildlife species are poor. The lack of shading riparian vegetation and degraded channel structure in Canyon Creek result in high stream temperatures during base flow periods in warm-weather years, which is limiting to cutthroat trout and other salmonid species of concern.

The water quality of Canyon Creek declines from the headwaters to the mouth. At the headwaters above O'Neill Gulch, measured concentrations of cadmium, lead, and zinc in surface water rarely exceeded acute and chronic AWQC except in the case of lead, where the chronic AWQC was exceeded in 7 of 12 samples (Stratus 1999a). From O'Neill Gulch downstream to the confluence with the South Fork Coeur d'Alene River, chronic lead and acute and chronic zinc AWQC were regularly exceeded. In a laboratory toxicity test, rainbow trout were exposed to various dilutions of Canyon Creek water for 96 hours. Trout mortality was zero in the control water, but increased to 100 percent in the 100 percent Canyon Creek water (Stratus 1999a).

Cutthroat trout are present in the watershed upgradient of the point where mining and other impacts start to intensify in CCSeg02 (Stratus 1999c 1999d). Salmonid populations are depressed from this point downstream due to a combination of factors. Fisheries population surveys conducted by the Natural Resource Trustees resulted in the capture of only two trout in the lower portion of the watershed over a 2-year sampling period, thus indicating that fish populations are severely depressed in the heavily modified areas of the watershed.

The taxa richness of the macroinvertebrate community in CCSeg01 and the uppermost portion of CCSeg02 is comparable to that observed in reference streams (an average of 10.7 species observed, versus 10.7 to 16.0 seen in reference streams). An average of 7.7 species was observed in the lower portion of the watershed with the reduction due to loss of the metals-sensitive mayfly species.

2.2.3.1.3 Ninemile Creek. Habitat conditions in the Ninemile Creek watershed vary considerably from the headwaters to the mouth of the system at Wallace. The headwaters of the stream, located in the upper portions of NMSeg01 and 03, are relatively undisturbed with intact and well-vegetated riparian zones, stable stream banks, and a diverse distribution of substrate types. Mining-related impacts to the stream channel and riparian zone begin at the downstream end of NMSeg01 and continue to the streams discharge point at Wallace.

Upland Habitat. The upland habitat of the Ninemile Creek Watershed has been modified by mine exploration/development and timber harvesting. Extensive timber harvesting has been conducted recently in the headwaters area of this watershed, particularly along the crest and slopes of NMSeg03. The extent of habitat modification is reflected in the high road densities present in the watershed, as shown in Table 2.2.3-1. The total road density is 6.8 miles per square mile, of which 5.8 miles per square mile are forest access or other low-speed unsurfaced roads.

Riparian Habitat. Riparian habitats on the middle to lower reaches of the watershed have been degraded due to development and mining related-activities. The central portion of the watershed has been channelized to protect roads, residences, and mining-related facilities. Given the degraded conditions of the habitat, riparian-dependent wildlife species will be limited or absent in these areas.

Riverine Habitat. Water quality in Ninemile Creek declines from the headwaters to the mouth at Wallace. Surface water samples collected in the headwaters above the Interstate-Callahan Mine had measured concentrations of cadmium, lead, and zinc that rarely exceeded acute and chronic AWQC except in the case of lead, where the chronic AWQC was exceeded in 4 of 12 samples (Stratus 1999a). From the Interstate-Callahan Mine downstream to the confluence with the South Fork, chronic lead and cadmium and acute and chronic zinc AWQC were regularly exceeded.

Metals concentrations measured in the stream have been found to exceed levels limiting to aquatic species. The Natural Resource Trustees conducted fishery population surveys at three locations downstream of mining influences in Ninemile Creek in 1994 and 1995 (Stratus 1999a 1999c 1999d). No fish were captured at any location during either period. The stream system is also impacted by channel degradation and the lack of shade, which contributes to high stream temperatures during low baseflow periods in warm-weather years.

Macroinvertebrate community studies in the Ninemile Creek watershed indicate that species diversity and abundance are depressed compared to reference areas. Taxa richness increased between survey locations in the headwaters and the lower watershed, from 7.0 to 8.7 species present, respectively.

2.2.3.1.4 Big Creek. The Big Creek Watershed has had relatively little mining activity in comparison to other watersheds in the basin. Active mining operations associated with the Sunshine Mine and Mill Complex have impacted riparian and riverine habitats in the lower reaches (BigCrkSeg04). Impacts include loss of riparian vegetation and channel structure that are visible in aerial photographs (URS and CH2M HILL 1999). Habitat data for the watershed are limited; however, available data indicate that upstream segments above the zone of mining-related influences on Big Creek are relatively intact in comparison to other watersheds in the basin.

Upland Habitat. The upland areas of the watershed have been subject to some historical exploration, but mining activity has been limited to the lower areas of BigCrkSeg04, leaving the remainder of the watershed relatively undeveloped. This is reflected in the road density figures for the watershed shown in Table 2.2.3-1. The overall road density for the watershed is 2.1 miles per square mile, with the majority concentrated in BigCrkSeg04. Road densities in the upstream segments are the lowest in the basin, ranging from 1.5 to 2.1 miles per square mile.

Riparian Habitat. Aerial photographs of the watershed indicate that riparian habitat in BigCrkSeg04 associated with the Sunshine Mine and Mill Complex is degraded. In the remaining segments of the watershed, some riparian habitat has been impacted by the development of forest roads, but overall road densities are lower than those observed in other watersheds in the assessment area. In general, conditions observed in aerial photographs of the Big Creek watershed appear to be comparable to those in reference watersheds (URS and CH2M HILL 1999).

Riverine Habitat. Based on estimates of trout and sculpin population density observed over a 3-year period (Stratus 1999a 1999c 1999d), the fish populations in the watershed are comparable to those observed in reference streams and other less heavily modified watersheds throughout the basin. The trout species present were a mixture of native cutthroat and introduced brook trout, with native cutthroat trout predominant. The observed trout population was higher in the upstream areas of the watershed, reflecting the lower degree of disturbance when compared to that in BigCrkSeg04. Sculpin were also present in the watershed at both upstream and downstream locations, but were far more prevalent at the upstream location, again reflecting the lower degree of anthropogenic impacts.

Macroinvertebrate taxa richness in the watershed is comparable to that observed in reference areas. Macroinvertebrate taxa richness has been measured at three locations in the Big Creek watershed. A total of 13.7 taxa were observed at the lower Big Creek location (above the Sunshine Mill Complex), and 11.0 taxa were observed at the upper Big Creek location surveyed by R2 Resources (Stratus 1999a).

2.2.3.1.5 Moon Creek. The Moon Creek Watershed has been subject to mining-related impacts associated with the Silver Crescent Mine and Charles Dickens Mine located near the headwaters of MoonCrkSeg02. Impacts include modification of uplands and riparian habitats for mill site development, and floodplain settling areas for tailings and slurries associated with floatation mining. The BLM has identified as a source area the tailings settling areas in upper Moon Creek, and has identified the length of Moon Creek, from the settling areas downstream to the confluence with the South Fork Coeur d'Alene River, as a floodplain area impacted by mining. Cleanup actions have been implemented at the above mill sites and tailings deposits under an engineering evaluation and cost analysis prepared for the U.S. Forest Service (Ridolfi 1996). These actions centered primarily on the isolation of source areas, and treatment of groundwater and seepage to limit mass loading to surface water.

Upland Habitat. Habitat data for the watershed reflect the impacts of mining, timber harvesting, and related resource extraction activities. Road density in the watershed totals 3.4 miles per square mile, of which 0.5 mile per square mile is primary access road, and 2.9 miles per square mile are forest access roads.

Riparian Habitat. As discussed above, the BLM has identified the riparian and floodplain areas downstream of the mine waste settling areas as impacted zones. Habitat data indicate that riparian and riverine habitat structure in Moon Creek is mildly degraded. However, photographs of riparian habitat conditions at habitat survey locations in the Moon Creek watershed, selected to be representative of watershed conditions, show a thick riparian vegetation structure of deciduous trees and shrubs (IDEQ 1999).

Riverine Habitat. Riverine habitat conditions in the Moon Creek Watershed are mildly degraded. This is reflected in available information on fish and invertebrate populations. Based on 2 years of sampling data, estimates of fish population density in the watershed indicate that the trout population of this system is comparable to that observed in reference streams and exceeds those of other mining-impacted watersheds. The observed trout population is represented by introduced brook and native cutthroat trout; however, sculpin were not observed during either sampling year, suggesting that the native fish population is depressed due to mining impacts on water and habitat quality (Stratus 1999c 1999d).

In addition, the taxa richness of the macroinvertebrate community in the lower portion of the watershed is depressed relative to reference watersheds, which suggests that water quality and habitat quality downstream of mining activities are degraded. Taxa richness in the upper West Fork Moon Creek, which is not heavily impacted by mining activities, is relatively low but comparable to reference streams. A taxa richness of 7.0, including 2.3 mayfly species, was measured at a location on the lower main stem, and a taxa richness of 9.7, including 3.3 mayfly species, was measured at a location in the upper West Fork Moon Creek (IDEQ 1999; Stratus 1999d 1999c).

2.2.3.1.6 Pine Creek. The Pine Creek Watershed has been subject to extensive mining activity in East Fork Pine Creek and along the main stem in the lower reaches of the watershed, PineCrkSeg01 and PineCrkSeg03, respectively. West Fork Pine Creek (PineCrkSeg02) has been subject to little mining-related activity, although other anthropogenic impacts, including residential development, forest roads, and timber harvest, are present.

Upland Habitat. Upland habitats in the Pine Creek drainage have been subject to variable levels of anthropogenic disturbance. Road density in the Pine Creek watershed is moderate compared to other watersheds in the basin at 3.5 miles per square mile. Of this total, 0.4 mile per square mile are primary paved roads within the Pinehurst city limits or local roads paralleling stream channels. The remaining 3.1 miles per square mile are unsurfaced access or forest roads, the majority of which are concentrated in PineCrkSeg02.

Riparian Habitat. Field observations and aerial photographs indicate that the riparian vegetation of the watershed has been degraded (URS and CH2M HILL 1999). The stream banks and floodplain areas of PineCrkSeg01 and PineCrkSeg03 have been impacted by releases of mining-related hazardous substances. Riparian habitats have been degraded and may be limiting to riparian wildlife species. Extensive stream channel and floodplain remediation activities have been conducted in these areas by the BLM.

The lower portion of PineCrkSeg03 lies within the town of Pinehurst. The stream system in this area is urbanized. There is extensive channelization and limited riparian vegetation. The remainder of this segment and East Fork Pine Creek have also been impacted by mining-related and other activities that resulted in the degradation of riparian and floodplain habitat.

needs to be explained

Riverine Habitat. Surface waters in East Fork Pine Creek above the Constitution Mine site regularly exceed chronic AWQC for lead (Stratus 1999a). Water samples taken between the Constitution Mine and West Fork Pine Creek regularly exceed acute and chronic AWQC for cadmium and zinc, and chronic AWQC for lead. Surface waters from the West Fork downstream to the confluence with the South Fork Coeur d'Alene River occasionally exceed acute AWQC for cadmium and lead, and regularly exceed acute and chronic criteria for zinc.

Fish populations in the watershed appear to be variable and depressed, based on estimates of population density observed over a 2-year period (Stratus 1999a 1999c 1999d). The fish population is dominated by brook trout, with native cutthroat trout making up a small proportion of the samples taken during one year, and absent the following year. Sculpin were not encountered at any location during either sampling year, reflecting their sensitivity to anthropogenic impacts and water quality.

Taxa richness of macroinvertebrate species in the main stem of Pine Creek is generally comparable to that found in reference areas. Taxa richness in PineCrkSeg01 was more variable, ranging from 8.7 to 15, depending on location. A total of 12 taxa were observed at one location in PineCrkSeg02.

2.2.3.1.7 South Fork Coeur d'Alene River. MidGradSeg01 includes the South Fork Coeur d'Alene River from Canyon Creek to Montgomery Creek. The segment includes several tributaries, the largest of which is Placer Creek, which flows into the South Fork Coeur d'Alene River in the town of Wallace immediately downstream of Ninemile Creek. MidGradSeg02 includes the South Fork Coeur d'Alene River from Montgomery Creek downstream to the confluence with the North Fork Coeur d'Alene River. The majority of this segment lies within the boundaries of the Bunker Hill Superfund site, and incorporates the towns of Kellogg, Smelterville, and Pinehurst

Upland Habitat. Upland habitats in MidGradSeg01 and MidGradSeg02 range from relatively undisturbed to degraded. Upland habitats within the Bunker Hill Superfund site have been denuded by airborne emissions from mining facilities, and recovery has been impeded by erosion of surface soils. However, restoration of hillside vegetation is being done within the Bunker Hill Superfund site. Mining-related exploration and development have impacted other upland habitats in the watershed. Some areas, such as the Placer Creek drainage, have seen relatively little mining or timber harvesting and upland habitat conditions are not considered degraded.

Road densities in MidGradSeg01 and MidGradSeg02 are relatively high at 5.3 miles per square mile (see Table 2.2.3-1). The majority of this road density is in association with urbanized and industrial areas. Low-speed gravel and forest access roads account for 3.8 miles per square mile (this may include low-speed roads in urban areas). Anthropogenic impacts in upland habitats vary by location, with some areas relatively undisturbed and other areas heavily degraded by past atmospheric deposition of contaminants and ongoing fluvium deposition of contaminants, with very limited wildlife habitat present.

Riparian Habitat. Riparian and floodplain habitats in MidGradSeg01 and MidGradSeg02 have been extensively degraded, due to the influences of channelization; urban, residential, industrial, and transportation infrastructure development; and the impacts of mining-related hazardous substances. Given the degraded habitat conditions, riparian-dependent wildlife species will be limited or absent in these areas.

Riverine Habitat. Riverine habitats in MidGradSeg01 have been extensively modified for transportation, residential, industrial, and urban development. These habitats have also been impacted by large ~~inputs of bedload material, tailings, and sediment from historical mining-related activities.~~ The river is channelized adjacent to I-90 along the entirety of its length. Due to these impacts, riverine habitat conditions and water quality throughout the segment are degraded. The large inputs of bed ~~material and sediments have resulted in bank instability and~~ erosion, substrate mobility, channel instability, filling of pools, widening of the stream channel, and other undesirable changes in channel structure. These impacts, and a lack of shading vegetation due to degraded riparian habitat conditions, result in stream temperatures that are limiting to fish and invertebrate species during warm-weather years.

Water quality conditions on the lower South Fork Coeur d'Alene River are compromised by the presence of heavy metals caused by mining-related activities, and nutrient pollution from untreated domestic waste. Measured concentrations of cadmium and zinc in surface water between Canyon Creek and the confluence with the North Fork Coeur d'Alene River routinely exceeded acute and chronic AWQC. Lead concentrations in surface water occasionally exceed AWQC (Stratus 1999c).

Various surface water toxicity studies have been conducted over the past four decades and include both in situ bioassays and laboratory tests on fish performed with water/mine effluents collected from the site (Stratus 1999c). Both types of studies have consistently demonstrated that exposure to water from the Coeur d'Alene River and contaminated tributaries is acutely lethal to fish. For example, several investigators conducted in situ toxicity tests by placing rainbow trout in cages at various locations on the South Fork and reference areas and exposing the fish to natural waters for a variable period of time. Results of these tests show that mortality was much higher (sometimes 100 percent) for trout exposed to natural water collected from sites downstream of Canyon Creek. The high mortality rates were associated with elevated concentrations of cadmium and zinc; other measured water quality parameters (e.g., dissolved oxygen, temperature, ammonia) were not at levels expected to cause adverse effects.

Laboratory toxicity tests (Stratus 1999c) demonstrated that cadmium and zinc are acutely toxic to salmonids. Metals were added to either water collected from clean tributaries of the South Fork Coeur d'Alene River or water formulated to match conditions present in the system. The concentrations of hazardous metals that were observed to have toxic effects were lower than federal water quality criteria levels, and substantially lower than concentrations of metals, particularly cadmium and zinc, routinely measured in surface waters of the assessment area. For example, in one acute test of 96 hours, hatchery cutthroat trout 3 to 4 cm long were exposed to water that had been collected from the South Fork Coeur d'Alene River upstream of Pine Creek and prepared at a range of dilutions from 0 to 100 percent river water. Mortality approached 100 percent for all dilutions except 0 and 3.1 percent river water (Stratus 1999c).

Trout populations in the lower South Fork Coeur d'Alene River below Wallace are depressed relative to populations in reference streams. This is an indication of the degraded habitat and water quality conditions present in this portion of the segment. Sculpin, a species believed to be sensitive to metals contamination and other anthropogenic impacts, were not observed in any fisheries population surveys in the South Fork Coeur d'Alene River below Wallace (Rahel 1999; Reiser 1999; Stratus 1999b 1999c). As discussed above, metals contamination levels present in surface waters have demonstrated toxic effects on trout species present in the assessment area. Aquatic habitat conditions in this portion of the river have also been degraded by the secondary effects of mining-related hazardous substances, and by other anthropogenic influences. Degradation of physical habitat structure is also limiting to fish populations.

As with the fish population, taxa richness of the macroinvertebrate community of the lower South Fork Coeur d'Alene River is depressed. Taxa richness ranged from 7.3 to 10.0 at three survey locations. The species present were primarily Dipterans (midges and blackflies), which are known to have a higher tolerance for metals contamination than other species (Stratus 1999c).

2.2.3.1.8 Prichard Creek. The Prichard Creek Watershed has been subject to several sources of anthropogenic disturbance, including mining-related activities, timber harvesting, and residential, urban, and transportation infrastructure development. Mining is active in the Eagle Creek drainage, a tributary watershed to lower Prichard Creek.

Upland Habitat. Limited information is available on upland habitat conditions in the Prichard Creek Watershed. Upland habitats have been impacted by mining-related activities, including placer mining near the headwaters. Active mining-related exploration and activity is occurring in the Eagle Creek drainage. The total road density in the Prichard Creek Watershed is 3.9 miles per square mile, of which 0.4 mile per square mile is primary paved roads, and 3.5 miles per square mile are low-speed unsurfaced access and forest roads. A large portion of this road density is associated with the towns of Prichard, Eagle, and Murray.

Riparian Habitat. The riparian vegetation conditions observed in aerial photographs indicate that riparian habitats in some areas of the watershed have been degraded by deposition of tailings and sediment bedload associated with mining activities (URS and CH2M HILL 1999).

Riverine Habitat. Historical placer mining practices introduced large volumes of sediment and tailings into the river system, which impacted stream habitat. Estimates of trout population density in Prichard Creek were derived from surveys conducted at two locations in 1994 and three locations in 1995 (Stratus 1999b 1999c). Trout density in the upper watershed was comparable to that observed in reference watersheds, while the trout population in lower Prichard Creek appears to be depressed. The population is dominated by introduced brook trout, with native cutthroat trout a minority component. Sculpin presence was monitored at three locations over 3 years. Sculpin were absent at middle and headwaters survey locations during all years, and were absent from the downstream survey location for 1 year. The limited and variable distribution of sculpins suggests impacts to habitat and water quality are affecting the native fish population (Rahel 1999).

The taxa richness of the macroinvertebrate community was surveyed at six locations distributed throughout the Prichard Creek Watershed (Stratus 1999c 1999d; IDEQ 1999). Macroinvertebrate taxa richness ranged from 10 to 20 between these locations, comparable to reference area streams.

2.2.3.1.9 Beaver Creek. The Beaver Creek Watershed has been subject to mining-related activities, timber harvesting, and other anthropogenic stressors. Active mining is occurring in the watershed in association with the Carlisle Mine and Mill site.

Upland Habitat. Little information on the current ecological status of upland habitat in the Beaver Creek Watershed has been identified.

Riparian Habitat. Little information on the current ecological status of riparian habitat in the Beaver Creek Watershed has been identified.

Riverine Habitat. Trout populations in the Beaver Creek Watershed appear to be low but generally comparable to those observed in reference streams. The trout population is represented by a mixture of native cutthroat, introduced rainbow and cutthroat trout hybrids, and introduced brook trout (Stratus 1999b).

The taxa richness of the macroinvertebrate community in the Beaver Creek Watershed appears to be comparable to reference locations. Totals of 14 and 20 taxa were measured at upstream and downstream survey locations, respectively, comparable to or exceeding taxa richness at reference locations (IDEQ 1999).

2.2.3.1.10 North Fork Coeur d'Alene River. The North Fork Coeur d'Alene River within MidGradSeg03 has had relatively little impact from hard rock mining compared to other areas in the project area. This portion of the watershed has been developed for transportation, agricultural, and residential use.

Upland Habitat. Timber harvesting in tributary watersheds to the North Fork Coeur d'Alene River, and associated forest road density, are extensive. This contributes to sediment loading in the North Fork and main stem Coeur d'Alene River. Road densities in MidGradSeg03 are shown in Table 2.2.3-1. Total road density is 3.7 miles per square mile, of which 0.8 mile per square mile are primary paved roads, and 2.9 miles per square mile are unsurfaced access or forest roads.

Riparian Habitat. Available data on riparian vegetation structure in MidGradSeg03 indicate that current riparian habitat conditions are comparable to those observed in reference streams and are not considered to be degraded. The riparian habitat of the North Fork should be able to support a diverse and abundant wildlife community.

Riverine Habitat. The North Fork supports an active sport fishery for several salmonid species, suggesting that the trout population is not depressed compared to reference conditions. No information on other native species (e.g., sculpin) was identified and the current status of these populations can not be determined at this time. As noted above, high forest road density and related timber harvest activities contribute to sediment loading in this segment, which can negatively impact the quality of riverine habitate.

The taxa richness of the macroinvertebrate community in MidGradSeg03 is comparable to or exceeds that observed in reference streams. An average of 27 taxa were observed at survey locations during 1987 to 1988 sampling period (Stratus 1999c).

2.2.3.2 CSM Unit 3

CSM Unit 3 encompasses the low-gradient portions of the main stem Coeur d'Alene River beginning at Cataldo and ending at Coeur d'Alene Lake near the town of Harrison. CSM Unit 3 is divided into six segments, each including a mix of riparian, riverine, palustrine, lacustrine, and agricultural habitats. While the following paragraphs discuss conditions by habitat, there can be considerable overlap of habitats in CSM Unit 3. The ecological status of the habitats in CSM Unit 3 was rated in the *Draft Current Status CSM* (CH2M HILL 1998) as degraded to medium.

The main stem Coeur d'Alene River and associated lateral lakes have been impacted by transport and deposition of tailings from upgradient mining areas. The active bed of the Coeur d'Alene River contains about 9 million cubic yards of mining-waste-contaminated alluvium as sand and silt. Measured concentrations of cadmium and zinc in surface water from the Coeur d'Alene River routinely exceeded acute and chronic AWQC; measured concentrations of lead regularly exceeded chronic AWQC (Stratus 1999b). Concentrations of cadmium, lead, and zinc in sediments from the Coeur d'Alene River and lacustrine and palustrine habitats of the lateral lakes routinely exceeded the ecological thresholds for the protection of benthic invertebrate communities (Stratus 1999b).

In addition to the impacts of mining-related hazardous substances, riverine and riparian habitats in CSM Unit 3 have been modified and otherwise influenced by a variety of historical and ongoing human activities. The hydrology of the lower reaches of the Coeur d'Alene River has been modified by the Post Falls dam on the Spokane River, creating an artificially managed environment. In addition, the main stem Coeur d'Alene River has been modified for flood control, transportation, and agricultural and residential development. These modifications have altered natural channel meander patterns and fragmented hydrologic connectivity between the river and its floodplain, and associated lacustrine and palustrine environments. Upstream land use impacts have resulted in recurrent loading of large volumes of sediment to the lower river, exceeding the transport capacity of the river and causing channel adjustments that have resulted in systematic bank failure throughout the lower river, exacerbated by recurrent disturbance from boat wakes. Extensive bank failure and sedimentation of the river has degraded riverine habitat quality in the main stem Coeur d'Alene River (Wesche 1999).

2.2.3.2.1 Lacustrine/Palustrine Habitats. The Coeur d'Alene River basin is located with the Pacific migration flyway and provides important habitat for migratory waterfowl and a diverse assemblage of aquatic and terrestrial species (Stratus 1999b). The lower Coeur d'Alene River and lateral lakes area contain abundant and diverse palustrine and lacustrine habitat that supports diverse wildlife uses including feeding, resting, and reproduction. More than 280 bird species are known or suspected to occur in the area.

Wildlife resources in the Coeur d'Alene River basin have been negatively affected by exposure to hazardous substances released from mining and mineral-processing facilities (Stratus 1999b). Lead was identified as the primary contaminant affecting wildlife in CSM Unit 3. Lines of evidence supporting this conclusion include:

- Ongoing exposure of wildlife to elevated levels of lead. Exposure is confirmed by the extremely high concentrations of lead in sediments (e.g., 500 to 20,000 ppm), high rates of sediment ingestion by wildlife, documented bioaccumulation of lead in the blood and tissues of multiple species of wildlife, and documentation of biological responses in wildlife occurring on the Coeur d'Alene River and lateral lakes that are characteristic of lead exposure.

- Multiple adverse effects caused by lead have been observed in wildlife in the Coeur d'Alene River. The biological responses observed in wildlife include death of large numbers and species, physiological malfunction, and physical deformities. Between 1992 and 1997, 189 tundra swans were found dead or sick in the Coeur d'Alene River basin versus 8 in a comparable reference location on the St. Joe River.

- Controlled laboratory studies have confirmed that the lead contained in sediment from the Coeur d'Alene River basin is bioavailable and causes adverse effects similar to those observed in the field.

The Coeur d'Alene River and lateral lakes contain a mixture of coldwater and warmwater fish species, with warmwater species dominating the lateral lakes. Laboratory studies conducted using cutthroat trout showed that trout avoided water containing cadmium, lead, and zinc at concentrations typical of those found at Cataldo and Harrison (Stratus 1999b). In a subsequent study, zinc was found to be primarily responsible for the avoidance response. The hypothesis that fish acclimated to the metals concentrations might show different avoidance responses was also investigated. Cutthroat trout were exposed for 90 days before testing with water containing concentrations of cadmium, lead, and zinc typical of those found at Harrison. The acclimated trout were then exposed to water containing concentrations of cadmium, lead, and zinc typically found at Cataldo, Harrison, and Coeur d'Alene Lake. Results showed that fish avoided water from Cataldo and preferred the water from Coeur d'Alene Lake that had the lowest metals concentrations.

what does this mean?

2.2.3.2.2 Riparian Habitat. Plant cover and species richness were measured in 39 sampling sites in the lateral lakes area and results suggest that the riparian vegetation has not been obviously degraded. Results of laboratory plant bioassays using soil collected from the field and four species of plants are reported in Stratus (1999b). The report groups the bioassay data into two broad categories: data from assessment area sampling sites and data from reference area sampling sites. Therefore, it was not possible to assess results of the bioassays specifically for CSM Unit 3. However, results of the assessment versus reference area comparisons showed that plant growth performance was significantly reduced in assessment soils relative to reference soils. Correlation analyses indicted that the majority of plant growth endpoints were significantly negatively correlated with concentrations of soil metals.

2.2.3.2.3 Riverine Habitat. Fish population assessment has been conducted in the lower Coeur d'Alene River using gillnet techniques that confirm the presence of reported fish species. However, the information gathered is too limited to use to draw conclusions about the current status of fish populations. Several salmonid species are known to inhabit the lower Coeur d'Alene River for all or part of their life cycles, or to transit the lower river during migration. Several exotic species have been introduced and have become established in the lower river basin as well, including rainbow trout, chinook salmon, bass, tench, northern pike, and tiger muskelunge. The introduction of non-native species has altered the trophic dynamics of the river system, with unknown effects on native fish species.

No recent information on the macroinvertebrate community composition of the main stem Coeur d'Alene River has been identified. Therefore, the current status of the macroinvertebrate community cannot be determined at this time.

2.2.3.2.4 Agricultural Habitat. Approximately 9,500 acres of agricultural land fall within the floodplain of the main stem of the Coeur d'Alene River in CSM Unit 3. Pasture and cultivated hay fields are the dominant agricultural land uses. The agricultural habitat is by definition highly modified by grazing and other agricultural practices. However, mining-related hazardous substances have affected this habitat. The surface soils on many of the low stream terraces along the Coeur d'Alene River that are used for agriculture are termed slickens and are composed of mill tailings that have been deposited with the annual alluvium (Frutchey 1994). Reclamation of affected agricultural soil is currently under way in certain areas.

2.2.3.3 CSM Unit 4

CSM Unit 4 encompasses Coeur d'Alene Lake and is composed of three discrete segments: CDALakeSeg01 includes the southern end of the lake below the mouth of the Coeur d'Alene River that is substantially influenced by the inflow of the St. Joe River; CDALakeSeg02 includes the main body of the lake, extending from the mouth of the Coeur d'Alene River to the north end of the lake at the head of the Spokane River, excluding the Wolf Lodge Bay arm of the lake; and CDALakeSeg03 is the Wolf Bay Lodge arm. CSM Unit 4 includes both lacustrine and palustrine habitats.

The *Draft Current Status CSM* (CH2M HILL 1998) rated the ecological status of the habitats in CSM Unit 4 as medium to good. The water quality of Coeur d'Alene Lake has been impacted by sediments, heavy metals, and other pollutants (R2 Resources undated). These pollutants are the result of extensive mining operations in the basin, ongoing timber harvest activity, and nutrient inputs from urban and domestic sources proximal to the lake (Woods and Beckwith 1997). Historically, nutrient enrichment in the southern part of the lake was caused by domestic sewage from cottages and boats and fertilizer from surrounding farmlands (Winner 1972). Nutrient inputs occurred primarily during late spring from the St. Joe and Coeur d'Alene Rivers, and Plummer Creek (Funk, Rabe, Filby, Parker et al. 1973). Extensive road systems and clearcutting have changed the timing and amount of water flowing from the heavily logged drainages, damaging stream and river channels and altering flood patterns (Woods and Beckwith 1997). Erosion rates from the agricultural areas can be among the highest in the nation and much of the sediment entering the southern end of Coeur d'Alene Lake and the bays on the western lakeshore comes from surrounding farms. Livestock grazing also has contributed to disturbance of tributary riparian areas, resulting in further nutrient and sediment transport to the lake. Coeur d'Alene Lake was considered mesotrophic during the mid-1970s, primarily due to nutrient pollution attributable to the above sources. Construction of municipal wastewater treatment facilities and the implementation of improved management practices for domestic waste, forest, and agriculture are credited with improving water quality to the point that the lake has been considered oligotrophic since the early 1990s (Woods and Beckwith 1997).

2.2.3.3.1 Palustrine Habitat. Few data were available to assess the ecological condition of the palustrine habitat in Coeur d'Alene Lake. However, the fact that the metals are present mainly in dissolved or fine particulate form has prevented accumulation of metals in sediments near shore or in shallow areas. Wave action and fluctuating lake levels winnow away from shallow water the fine sediments with which the metals are associated. An exception to this occurs at Harrison where deposition of either larger amounts of particles or larger particles has resulted in elevated metals concentrations in beach sediments.

2.2.3.3.2 Lacustrine Habitat. Lacustrine habitat is discussed in terms of biota communities and water quality.

2.2.3.3.3 Biotic Communities. Coeur d'Alene Lake contains a diverse mix of coldwater and warmwater fish species, many of which are introduced non-natives (Stratus 1999b). Coeur d'Alene Lake is heavily used for recreational boating and fishing and is a major regional attraction as a recreation and tourist area (Woods and Beckwith 1997). Kokanee salmon were introduced to the lake in 1937 and the population is self-sustaining and productive (IDFG 1980).

The native fish community in Coeur d'Alene Lake includes westslope cutthroat trout, bull trout, mountain whitefish, yellow perch, northern squawfish, suckers, and various species of sculpins (R2 Resources undated). A general decline in the native trout population and harvest has been documented over the last 25 years. Major reasons for this decline include habitat loss or degradation, overexploitation, and competition from introduced species. Historically, large populations of adfluvial-lacustrine westslope cutthroat trout and bull trout migrated to tributary streams, including the Coeur d'Alene River, to reproduce (R2 Resources undated). Much of the migratory, spawning, and rearing habitat in the Coeur d'Alene River has been detrimentally affected by reduced habitat quantity and quality, sedimentation, and heavy metals contamination from mining operations in the Silver Valley. Other tributary habitats have also been degraded by anthropogenic activities. Historical overharvesting, degradation of tributary habitat, loss and degradation of lake habitats, reduced lake water quality, and introductions of competing and predatory fish species have substantially reduced populations of native salmonids in Coeur d'Alene Lake. Exotic species introductions have also altered the trophic dynamics of the lake.

Studies of the macroinvertebrate communities of Coeur d'Alene Lake were conducted in 1971 (Winner 1972) and 1995 (Ruud 1996). Winner (1972) observed strong dominance of chironomids and oligochaetes in benthic macroinvertebrate communities of Coeur d'Alene Lake. He did not find a relationship between sediment zinc concentrations and the distribution of chironomids and oligochaetes. Ruud (1996) found that the macroinvertebrate communities in Coeur d'Alene Lake varied with depth and location. The south end of the lake has the highest biological productivity. The macroinvertebrate communities in Coeur d'Alene Lake differed substantially from those found in Priest Lake, considered a comparable reference area. Total abundance, total biomass, taxa richness, and mean diversity were positively correlated with zinc concentration in water. Trace elements were elevated in surface water and tissue of macroinvertebrates of Coeur d'Alene Lake relative to reference concentrations in Priest Lake. Body burdens were higher in deepwater sites and were relatively low in the southern portion of the lake.

2.2.3.3.4 Water Quality. Concentrations of a variety of inorganic substances in the sediments of Coeur d'Alene Lake are enriched in approximately 85 percent of the lakebed surface (Woods and Beckwith 1997). The metal-contaminated sediments tend to be very fine-grained (less than 63 μm), and are readily mobilized by currents within the lake. The thickness of the contaminated sediments ranges from 17 to over 119 cm, with the thickest deposits generally near the mouth of the Coeur d'Alene River (Horowitz et al. 1993). Concentrations of hazardous substances occur above sediment quality guidelines that are indicative of severe pollution, with the potential to significantly impact benthic organisms~~. However, it appears~~ that most of the trace elements are bound up with the sediment (Woods and Beckwith 1997). need a more recent summary

Concentrations of metals in waters of Coeur d'Alene Lake have the potential to affect aquatic organisms. Concentrations of cadmium and zinc measured in Coeur d'Alene Lake water exceeded the acute AWQC (Stratus 1999b); cadmium exceeded criteria in 32 of 37 samples and zinc in 91 of 93 samples. Exceedances were also reported for site-relevant thresholds that were developed for the basin. Phytoplankton bioassays in chemically-defined media showed that dissolved, uncomplexed concentrations of zinc typical of much of Coeur d'Alene Lake were strongly inhibitive to growth of three phytoplankton isolates from the lake (Woods and Beckwith 1997). Woodward et al. (1997) investigated the effects of metals concentrations in Coeur d'Alene Lake water on cutthroat trout. Cutthroat trout evidenced significant avoidance of test waters containing mixtures of hazardous substances representing the metals concentrations in Coeur d'Alene Lake (Stratus 1999b). Zinc was found to be primarily responsible for the avoidance. A subsequent test evaluated the role of acclimation of fish to sublethal metal concentrations in the avoidance response. Water with metals concentrations representative of locations at the Coeur d'Alene River at Cataldo, the Coeur d'Alene River at Harrison, and Coeur d'Alene Lake were tested. Acclimated fish were found to prefer the lake waters that had the lowest metals concentrations.

Extensive residential and commercial development of the drainage basin and shoreline, plus intensive recreational use of Coeur d'Alene Lake, have created considerable concern over the potential for nutrient enrichment and subsequent eutrophication of the lake. Under eutrophic conditions, increased production of phytoplankton could cause reduction of oxygen levels in the deeper waters of the lake to a point where the altered state would allow the release of bound metals found in lake sediments. However, results of analysis of the lake system by Woods and Beckwith (1997) show that the lake has a large assimilative capacity for nutrients without causing the reductions in oxygen that might cause enhanced releases of metals.

Lower dissolved oxygen concentrations have been identified as a potential problem in Coeur d'Alene Lake. Winner (1972) reported that dissolved oxygen levels declined to 1 mg/L in the southern part of the lake and 4 mg/L in other areas and concluded that the low levels of dissolved oxygen in the southern part of lake could inhibit aquatic biota. Funk, Rabe, Filby, Parker et al.

(1973) recorded dissolved oxygen levels below 2 mg/L in some areas during late summer. A 1987 study (Woods 1989) showed that dissolved oxygen concentrations continued to have minimum values as low as 4 mg/L. Woods and Beckwith (1997) hypothesized that as uncomplexed zinc concentrations increase from south to north in the lake, concentrations become highly inhibitory to phytoplankton growth. The dead or dying phytoplanton then settle into the deeper, cooler water in the northern basin of the lake and produce a dissolved oxygen deficit when the lake is thermally stratified.

2.2.3.4 CSM Unit 5

CSM Unit 5 encompasses the riverine and riparian habitats of the Spokane River from its head at Coeur d'Alene Lake west to the confluence with Lake Roosevelt, the Columbia River impoundment behind Grand Coulee Dam. CSM Unit 5 is composed of three segments: SpokaneRSeg01 extends from Coeur d'Alene Lake to the Washington-Idaho state line and includes the Post Falls dam; SpokaneRSeg02 extends from the state line to the upper end of the Long Lake Reservoir; and SpokaneRSeg03 extends from the upper end of the Long Lake Reservoir to the confluence with Lake Roosevelt. The assessment area within CSM Unit 5 includes riverine, lacustrine, and riparian habitats. For the purpose of this discussion, riverine and lacustrine habitats are considered together.

The ecological status of habitats in CSM Unit 5 was rated medium to good in the *Draft Current Status CSM* (CH2M HILL 1998). Studies of water quality conducted in the 1970s and 1980s indicate that water quality at that time was generally good above the city of Spokane, but declined downstream from the city due to point- and nonpoint-source pollution (Falter and Mitchell 1982; Funk, Rabe, Filby, Parker, et al. 1973; Funk, Rabe, Filby, Bailey, et al. 1973; Gibbons et al. 1984).

2.2.3.4.1 Riparian Habitat. The Spokane River is subject to a variety of anthropogenic influences along most of its length (Falter and Mitchell 1982; Funk, Rabe, Filby, Parker, et al. 1973; Funk, Rabe, Filby, Bailey, et al. 1973; Gibbons et al. 1984). Urban development occurs along the upper half of the river, where the city of Spokane is the major population center. The river was found to be in a mesotrophic condition due to nutrient inputs and oxygen-demanding inputs, and also found to have elevated levels of metals, particularly zinc, in the water column and sediments. These researchers further stated that direct and subsequent impacts to the fish and invertebrate communities could be attributed to metals pollution, and the effects of nutrient pollution from point and nonpoint sources. The river has been dammed at several locations for flood control, hydropower production, and water storage. Water withdrawals for agricultural and urban use influence hydrologic patterns and water quality. Nitrogen supersaturation occurs in the river below Post Falls. The impact of these types of influences on riverine ecosystems has been well documented (Karr 1991; Naiman et al. 1992a 1992b; Spence et al. 1996).

Mining activities in the Coeur d'Alene River Basin have contributed to elevated levels of zinc and other metals in the Spokane River. Metals discharged from Coeur d'Alene Lake in dissolved and particulate form are carried down the Spokane River. Point-source pollution from municipal sewage discharge, industrial uses, and other sources, and nonpoint-source pollution from agriculture and stormwater runoff, influence water quality. Nine Superfund sites occur within

CSM Unit 5 and six major facilities are permitted under the National Pollution Discharge Elimination System (NPDES) to discharge into the Spokane River and its tributaries (Maret and Dutton 1999).

A narrow band of riparian vegetation borders the Spokane River for most of its length. River banks and riparian zones have been modified for flood control, and agricultural, residential, and recreational purposes. The riparian vegetation in the reach extending from the Monroe Street dam to the upper portion of the Long Lake Reservoir was qualitatively rated as sparse during a 1987 survey (Kleist 1987). The sparse vegetation was attributed to the dynamics of floodplain transitions created by the river or the steep and/or rocky terrain through which the river flows.

2.2.3.4.2 Riverine/Lacustrine Habitats. Sediment samples were collected from 14 sites on the Spokane River in 1998 and analyzed for priority pollutant metals (Johnson 1999). For the main stem of the Spokane River, sediment guidelines for the protection of aquatic organisms were exceeded in 10 of 10 samples for zinc, 6 of 10 for cadmium, and 5 of 10 for lead. Fine-grained sediment in the Spokane River is contaminated with cadmium, lead, and zinc, with generally decreasing concentrations from upstream to downstream. Riverbed substrate conditions range from cobbles in the free flowing reaches to fine-grained material in the reservoirs where reduced water velocity allows the fine-grained materials to settle out (Kleist 1987). Distinct benthic invertebrate communities are found in the different substrate types (Kleist 1987).

Reference

During high flows, concentrations of dissolved lead and zinc exceed the AWQC in the Spokane River. Concentrations of dissolved metals decrease with distance down the Spokane River during lower flows, in part because of exchange of water between the river and the aquifer, but also perhaps in part because of precipitation of metals caused by increased alkalinity discharged from the aquifer. The alkalinity added by the aquifer provides the added benefit of reducing the toxicity of the remaining metals.

In addition to metals, polychlorinated biphenyls (PCBs) were found to be elevated in aquatic organism tissue samples collected from the Spokane River (Maret and Dutton 1999). Total PCB concentrations in all 52 tissue samples of fish from the Spokane River in Washington exceeded guidelines for the protection of human health and predatory wildlife. The Washington State Department of Ecology (1996, as cited in Maret and Dutton 1999) identified PCBs as one of the contaminants responsible for impaired uses on the Spokane River in its Section 305(b) water quality status report.

The fish community of the Spokane River is diverse and moderately productive. More than 20 species of fish have been identified in the Spokane River, many of which have been introduced to provide enhanced recreational opportunities (Bennett and Underwood 1988; Kleist 1987; Maret and Dutton 1999). Kleist (1987) reports that more than 1 million salmonids were introduced to the Spokane River between 1948 and 1987. Annual growth of introduced rainbow trout in the river is good, especially during their first year (Bennett and Underwood 1998). The Spokane River from Post Falls dam to the upriver dam pool supports a moderately productive rainbow trout fishery based in part on natural reproduction and in part on planted fish (Bennett and Underwood 1988; Johnson 1997). A tournament largemouth bass fishery exists in the Long Lake Reservoir (Pfeiffer 1985). There is a high abundance of nongame fish (e.g., northern pike, minnow, suckers) in the impounded waters of the Spokane River (Pfeiffer 1985).

A high level of annual mortality (greater than 70 percent) was reported for the rainbow trout population in the upper Spokane River during a study conducted in 1985 and 1986; annual fishing mortality made up less than 10 percent of that rate (Bennett and Underwood 1988). The elevated annual natural mortality could be related to postspawning mortality~~, high zinc~~ concentrations, elevated summer temperatures, and~~/or low summer~~ flows. Mean annual discharge in the Spokane River at Post Falls from 1953 to 1968 was 6,922 cfs (196 m^3/s). However, flows over that period were extremely ~~variable, ran~~ging from 2.5 to more than 1,416 m^3/s. During a low-flow event in 1986, streamflows dropped below 6,000 cfs and substantial areas of spawning substrate were exposed during incubation, resulting in low survival of rainbow trout fry. Johnson (1997) concluded that rainbow trout spawning success in the upper Spokane River appears to be strongly dependent upon fish initiating spawning early in the season (beginning of April) to ensure adequate time for fry development and emergence prior to streamflow decline.

More recent data?

The diversity of the invertebrate community in the Spokane River was found to be below what should be expected for a river of this size, location, and morphology (Falter and Mitchell 1982; Funk, Rabe, Filby, Parker, et al. 1973; Funk, Rabe, Filby, Bailey, et al. 1973; Gibbons et al. 1984). Kleist (1987) also reported a low diversity of benthic invertebrates, with diversity being lowest in impounded reaches of the river where midge larvae (family Chironomidae) were dominant. However, invertebrate densities appear to be sufficient to sustain a relatively large forage base (Pfeiffer 1985).

2.3 CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN

A preliminary list of chemicals of potential ecological concern (COPECs) was identified during the development of the draft Technical Work Plan (URS Greiner and CH2M HILL 1998). This list was reviewed and preliminary COPECs detected in sediment, soil, and surface water that met data evaluation requirements discussed below were carried forward through the analysis phase (Section 3.0). Final chemicals of ecological concern (COECs) were identified using a weight-of-evidence approach as discussed in Section 4.0.

2.3.1 Data Evaluation

The chemical data used in this EcoRA include concentrations of chemicals in both abiotic media (sediment, soil, and surface water) and biological media (plant and animal tissue). They were compiled from numerous site studies as described in the RI under the Nature and Extent section. The data evaluation protocols for the abiotic media data and the biological media are summarized below and those for the abiotic media are presented in greater detail in Appendix A.

The abiotic media data were evaluated initially using URSGs general data qualification review and reduction protocols and then the data set was further reduced for the specific uses of the EcoRA. The initial data qualification review and reduction was completed by URSG following data validation. The purpose of this review was to apply consistent rules for qualification of data independent of the laboratories or individual data validators, and then to resolve multiple values within a given sample to arrive at a single value per chemical per sample. The data qualification review included the following:

- Review of quality control sample results
- Review and selection of data qualifiers
- Derivation of data usability qualifiers

Following data qualification, the data set was reduced using an automated data selection processor. The data reduction routine is used to select the best value for each analyte or group of analytes by methods that include the following:

- Resolving multiple valid analyte values caused by dilutions, reanalysis, and laboratory duplicates

- Resolving multiple valid values caused by analytes measured across multiple methods in the same sample and method class

- Resolving multiple valid values caused by collection and analysis of field duplicates

- Computing total values for compound classes

- Carbon-normalizing sediment data

The reduction process for the EcoRA included correction of some inconsistencies within the database as well as the reduction of the database to the specific needs of the EcoRA (see Appendix A, Section A2.0). The database corrections included the following:

- Addition of zone information for samples missing it
- Consolidation of sample BV50 with BV1
- Correction of sample dates
- Removal and replacement of XRF data
- Removal of duplicate IDEQ data

The data reduction steps were:

- Limit to media of concern - sediment (database code SD), soil (codes SS, SB, SL, and FL), and surface water (code SW)

- Restriction of sample depths - sediment (0 - 0.5 ft bgs) and soils (0 - 5 ft bgs)

- Restriction of location types (see Table A2-1)

- Reduction to ecologically relevant common use areas (CUAs) (see Table A2-2)

- Removal of samples from Superfund Site (Box) (see Table A2-3)

- Removal of adit samples from CSM Unit 4

- Removal of data without zone information
- Removal of soil data with liquid units
- Addition of sample-specific habitat information
- Reduction to COPECs by medium

Chemical data for each abiotic medium meeting these requirements were retained for further evaluation in the EcoRA, and are presented in Appendix B. A summary by CSM Unit and habitat type including number of detects, number of samples, frequency of detection, and minimum and maximum detected concentrations is presented in Table 2.3.1-1. ***[[Note: Table may be moved into Appendix B.]]***

Numerous studies of the accumulation and transport of metals in biota in the Coeur d'Alene basin have been conducted over the years. These data may be segregated into three groups. Some data are suitable to estimate food-web exposures to consumer species (e.g., results from whole body analyses of fish, invertebrates, and small mammals; analyses of plant tissues). Other data are suitable for estimating metals exposure within the species from which the tissues were obtained (e.g., metal concentrations in target organs [liver, kidney, and blood]; measures of delta-aminoleuvulinic acid dehydratase [ALAD] inhibition in blood). The last group of data are not readily usable in ecological risk assessments. These data include metal concentrations in mammals hair, feathers, and fillet analyses of fish. In this section, summary statistics for biota data that are suitable for estimation of food-web exposures are presented. Other biota data, such as target organ data, will be presented ~~in the Exposure Analysis section~~ (Section 3.1).

Sources of biota data to be used for estimation of food-web exposure are summarized in Table 2.3.1.4-1. Whole-body metal concentration data were only available fish, aquatic invertebrates, small mammals. Concentration data in foliage or above-ground parts were available for aquatic and terrestrial plants. Most data were from CSM unit 3, with much less data from CSM units 1, 2, and 5; no whole-organism biological data were available from CSM unit 4 (Table 2.3.1.4-1).

couldn't find

Summary statistics for biota data to be used for estimation of food-web exposure are presented in Table 2.3.1.4-2. ***[[Preferable to move this table into an appendix?]]*** To evaluate if the distributions of the values for each biota type from each location were normally distributed, Shapiro-Wilk's test was performed. The null hypothesis that the observations were normally distributed could not be rejected approximately 50 percent (94 of 196) of the analyte-biota type-location combinations (Table 2.3.1.4-2).

2.3.2 Background Evaluation

Soil, sediment, and water background values are determined in Section 6.2 of the RI report ***[[Reference?]]*** where details of the methods and data used are presented. The basis for selecting background concentrations of COPECs in ambient surface water is summarized in Table 3.2.2-1. Examination of the table shows that there are some possible differences in background concentrations of metals in surface water depending on the geology of the source areas. For the purpose of screening COPECs, the 95th percentile of values for the entire South Fork Coeur d'Alene River basin were used (Table 3.2.2-1). Information on variation in background within the Coeur d'Alene River basin is used in later sections to qualify the results of comparisons of concentrations of metals in water with concentrations that are believed to cause harmful effects.

2.3.3 Identification of Chemicals of Potential Ecological Concern

The COPECs for the Coeur d'Alene River basin were tentatively identified during the evaluation of nature and extent of contamination in the draft Technical Work Plan (URS Greiner and CH2M HILL 1998). These chemicals were carried forward to the EcoRA and are the focus of all subsequent evaluations in this report. The list of COPECs evaluated is as follows:

- Sediment - arsenic, cadmium, copper, lead, mercury, silver, and zinc
- Soil - arsenic cadmium, copper, lead, and zinc
- Surface water - cadmium, copper, lead, and zinc

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data base has been updated since then

The COPECs in surface water were reviewed in December 1999. This survey was conducted on the database as it stood at that time. ~~The priority pollutant metals in surface water samples were screened against the national ambient~~ water quality criteria calculated at a hardness of 30 mg/L. Cadmium, copper, lead, and zinc concentrations commonly exceeded the criteria. Arsenic exceeded the chronic criterion only in two samples from adits. Silver was detected in only five samples, and did not exceed the acute criterion in any sample in the frozen data set used for EcoRA. Mercury was detected in only six samples, but exceeded the chronic criterion in only one adit sample, and the acute (and chronic) criterion in only one ambient surface water sample from near the mouth of Two-Mile Creek.

is this the reason

Because of the infrequent detection of mercury and silver, and relatively low concentrations when detected, mercury and silver were not selected as COPEC. Arsenic was not selected because concentrations did not approach the chronic ambient water quality criterion in any ambient surface water sample. Metals lacking ambient water quality criteria also were not selected.

2.4 ECOLOGICAL MANAGEMENT GOALS, ASSESSMENT ENDPOINTS, AND MEASURES

Ecological management goals, assessment endpoints, and measures for the Coeur d'Alene EcoRA are described in the following sections. The ecological goals, endpoints, and measures presented here are the result of discussions and comments from members of the EcoRA group, including the natural resource trustees.

Tribe

2.4.1 Ecological Management Goals

~~The ecological~~ management goals for this EcoRA were developed in consultation with the Coeur d'Alene Nation, the U.S. Fish and Wildlife Service, the U.S. Bureau of Land Management, and the U.S. Forest Service. The State of Idaho and the State of Washington have also participated in the development of these goals as they pertain to the natural resources entrusted to those stakeholders. The ecological management goals include the following:

- Maintenance (or provision) of soil, sediment, water quality, food source, and habitat conditions capable of supporting a "functional ecosystem" as discussed below for the aquatic and terrestrial plant and wildlife populations in the Coeur d'Alene River basin.
- Maintenance (or provision) of soil, sediment, water quality, food source, and habitat conditions supportive of individuals of special-status biota (including plants and animals) and migratory birds, protected under the Migratory Bird Treaty Act, likely to be found in the Coeur d'Alene River basin.

The overall objective for the EcoRA is to define the baseline or existing risks to ecological receptors and provide risk managers with the information needed to achieve the ecological management goals for the area and to make remedial decisions for each portion of the Basin. Inherent in these ecological management goals is the need to reduce the toxicity and/or toxic effects of hazardous chemicals released by mining activities to ecological receptors within the Coeur d'Alene River basin. By protecting the integrity of the food chain, water and other natural resources as well as habitat structure, the ecological management goals should be fulfilled. The ecological endpoints to evaluate these objectives are presented in the following sections.

2.4.2 Assessment Endpoints

Assessment endpoints for the Coeur d'Alene River basin were developed in collaboration with the natural resource trustees. The selection of the assessment endpoints is crucial to the EcoRA as they define the important ecological values of the Basin that are protected (Suter 1990 1993; Suter et al. 2000; USEPA 1996c 1997a 1998). They are developed based on known information concerning the contaminants present, the receiving site, and the risk management goals. In addition, they must represent a property of the system that can be measured. There are three components to each assessment endpoint: an entity (e.g., migratory birds), an attribute of that entity (e.g., individual survival), and a measurable value such as an effect level (USEPA 1998; Suter et al. 1995; Suter et al. 2000).

The entities for the assessment endpoints for the Coeur d'Alene River basin are based on the following principal criteria:

- ecological relevance;
- political and societal relevance;
- susceptibility to known or potential stressors at the site; and
- consistency with ecological management goals for the site.

The attribute selected for each entity was based on the organizational level of the entity and the primary criteria that were used to select it. Entities and attributes were selected for each of the following levels: individual-level; population-level; community-level; and habitat, ecosystem, and landscape-level.

The effect level selected for most of the assessment endpoints is a 20 percent reduction in the measured attribute. This level is consistent with current EPA regulatory practice (e.g., development of National Ambient Water Quality Criteria and effluent discharges regulated by the National Pollution Discharge Elimination System) and measurement limits for many field and laboratory tests (e.g., aquatic subchronic toxicity tests are not reliable at detecting reductions of less than 20 percent of the test organism, lowest observed effect concentrations [LOECs] for avian reproduction tests correspond to a 20 percent reduction, and 20 percent reduction in the community is the limit of detection for assessing aquatic communities using the EPA rapid bio-assessment procedures (Suter et al. 2000). As such, an initial effect level of 20 percent has been selected for all assessment endpoints in the Coeur d'Alene River basin with the exception of migratory birds and special-status species. Because migratory birds and special-status species are statutorily protected at the individual level, any adverse effect to their stated ecological attribute is considered unacceptable. Effect levels were considered in comparison to measures at comparable reference habitats.

The protection of assessment endpoints for the Coeur d'Alene River basin as a whole at the 20 percent effect level will be considered to result in a "functional ecosystem." The endpoints were reviewed for their relevance to the habitats and potential ecological receptors in each of the CSM units, which are described in Section 2.5. Table 2-1 presents the habitat-specific and CSM unit-specific endpoints for the Coeur d'Alene River basin EcoRA. The table represents a "stepping down" of the assessment endpoints to clarify which ones were evaluated for each habitat within each of the five CSM units. The assessment endpoints are described in the following sections.

2.4.2.1 Individual-level Endpoints

The following assessment endpoints pertain to potential effects on individuals of migratory bird and special-status species within the Coeur d'Alene River basin. The effect levels for these endpoints were established to eliminate adverse effects to individuals.

Entity A1: Migratory bird species protected by the Migratory Bird Treaty Act (16 USC 703 et seq.)

Attribute: Health, survival, and reproduction of individual migratory birds and the abiotic and biotic habitat conditions supportive of these species. Effects of "health" refers to adverse sublethal effects caused by mining-related hazardous substances that may be reasonably expected to impair survival (e.g., through increased susceptibility to disease or other causes of mortality) and/or reproduction).

Effect Level: Any exposure resulting in effects greater than expected at background, or exceeding toxicological screening crieria.

Entity A2: Special-status plant and animal species that are considered threatened or endangered, species of concern, or state-sensitive species.

Attribute: Health, survival, and reproduction of individuals, abiotic and biotic, and habitat conditions that are necessary to maintain current population and also conducive to future recovery of the species.

Effect Level: Any exposure resulting in effects greater than expected at backgrounds, or exceeding toxicological screening criteria are anticipated. Adequate habitat conditions to allow existing individuals to survive and reproduce.

2.4.2.2 Population-level Endpoints

The following assessment endpoints pertain to potential effects on populations of species that are characteristic of natural habitats within the Coeur d'Alene River basin. Effect levels for these endpoints were established to eliminate adverse effects that may be experienced by ≥20 percent of the naturally occurring populations.

Entity B1: Fish.

Attribute: Survival, reproduction, and abundance conducive to the maintenance of viable (self-sustaining) populations of individual species at levels that are characteristic of natural habitats in the region and supportive of the aquatic community structure.

Effect Level: Any exposure resulting in ≥20 percent reduction in attributes relative to reference or baseline data.

Entity B2: Amphibians.

Special status of bats?

Attribute: Survival, reproduction, and abundance conducive to the maintenance of viable (self-sustaining) populations of individual species at levels that are characteristic of natural habitats in the region and supportive of aquatic and terrestrial community structures.

Effect Level: Any exposure resulting in ≥20 percent reduction in attributes relative to reference or baseline data.

Entity B3: Other Birds. (or Non-migratory birds)

Attribute: Survival, reproduction, and abundance conducive to the maintenance of viable (self-sustaining) species populations at levels that are characteristic of natural habitats in the region and supportive of the community structure.

Effect Level: Any exposure resulting in ≥20 percent reduction in attributes relative to reference or baseline data.

Entity B4: Mammals.

Attribute: Survival, reproduction, and abundance conducive to the maintenance of viable (self-sustaining) species populations at levels that are characteristic of natural habitats in the region and supportive of the community structure.

Effect Level: Any exposure resulting in ≥20 percent reduction in attributes relative to reference or baseline data.

2.4.2.3 Community-level Endpoints

The following assessment endpoints pertain to potential effects within the Coeur d'Alene River basin on aquatic and terrestrial plant and invertebrate communities that are characteristic of natural habitats in the region. The effect levels for these endpoints were established to eliminate any adverse effects to individuals that comprise critical elements within aquatic and terrestrial plant and invertebrate communities.

Entity C1: Aquatic and Terrestrial Plant Communities.

Attribute: Aquatic and terrestrial plant community composition, density, species diversity, and community structure that provide suitable habitat and forage for indigenous wildlife species; survival and reproduction capable of maintaining viable populations of indigenous plant species that are characteristic of natural habitats in the region supportive of the aquatic and terrestrial community structure.

Effect Level: Any exposure resulting in ≥20 percent reduction in attributes relative to reference or baseline data.

Entity C2: Aquatic and Terrestrial Invertebrate Communities.

Attribute: Aquatic and terrestrial invertebrate community composition, abundance, density, species diversity, and community structure supportive of aquatic and terrestrial ecosystem processes (e.g., nutrient cycling, decomposition) as well as providing prey for aquatic and terrestrial predators; survival and reproduction capable of maintaining viable populations of indigenous invertebrate species that are characteristic of natural habitats in the region supportive of aquatic and terrestrial community structure.

Effect Level: Any exposure resulting in ≥20 percent reduction in attributes relative to reference or baseline data.

2.4.2.4 Habitat, Ecosystem, and Landscape-level Endpoints

The following assessment endpoints pertain to potential direct and indirect effects of mining-related hazardous substances on habitats, ecosystems, and the landscape within the Coeur d'Alene River basin.

Entity D1: Soil Processes.

Attribute: Soil microbial community viability and sustainability that are capable of supporting nutrient cycling and other ecosystem processes necessary for higher plants and animals.

Entity D2: Landscape Characteristics.

Attribute: Physical and biological landscape attributes, both at micro- and macro-scale levels, necessary for sustaining plant, and animal communities, including spatial extent of habitats, corridors connecting habitats, and mosaic of habitat types.

2.4.3 Measures

Both the assessment endpoints and the CSM (discussed in Section 2.5) help the risk manager and the risk assessor identify measurable attributes to quantify and predict change (USEPA 1998). There are three categories of measures: measures of exposure, measures of effect, and measures of ecosystem and receptor characteristics.

Measures of exposure are the contact or co-occurrence of the stressor and the assessment endpoint. An example of a measure of exposure is the concentrations of COPECs in sediment. Measures of effects are the quantifiable changes in an attribute of an assessment endpoint in response to a stressor. An example of a measure of effect is the effects on health, survival, or reproduction of migratory birds.

Measures of ecosystem and receptor characteristics are defined by USEPA (1998) as "measures that influence the behavior and location of ecological entities of the assessment endpoint, the distribution of a stressor, and the life-history characteristics of the assessment endpoint or its surrogate that may affect exposure in response to the stressor."

2.4.3.1 Measures of Exposure

The following bulleted items present the measures of exposure used in the Coeur d'Alene River basin EcoRA. These measures were developed for each of the assessment endpoints and habitats within each of the CSM units as listed in Table 2-1. The measures of exposure also are defined according to the potential exposure media within each of the habitats in each CSM unit. The draft measures of exposure for each unit, habitat type, medium, and assessment endpoint were included in the Draft Problem Formulation (URS Greiner and CH2M HILL 1999).

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The list of measures of exposure are:

- ~~Concentrations of COPECs in surface~~ water
- Concentrations of COPECs in biota
- ~~Concentrations of COPECs in sediment~~
- Concentrations of COPECs in soil

see p. 2-35

2.4.3.2 Measures of Effect

The following bulleted items present the measures of effects used in the EcoRA. As with the measures of exposure, these measures of effect were developed for each of the assessment endpoints and habitats within each of the CSM units as listed in Table 2-1. The measures of effects also are defined according to the potential exposure media within each of the habitats in each CSM unit. A draft of the measures of effects for each unit, habitat type, medium, and assessment endpoint was also provided in the Draft Problem Formulation (URS Greiner and CH2M HILL 1999).

The measures of effects are listed below:

- Effects on aquatic invertebrate community composition, abundance, density, species diversity, or community structure
- Effects on terrestrial invertebrate community composition, abundance, density, species diversity, or community structure
- Effects on aquatic plant community composition, density, species diversity, or community structure
- Effects on terrestrial plant community composition, density, species diversity, or community structure
- Effects on health, survival, or reproduction of migratory birds
- Effects on survival, reproduction, or abundance for other bird species
- Effects on health, survival, or reproduction of special-status biota
- Effects on survival, reproduction, or abundance for amphibian species
- Effects on survival, reproduction, or abundance for fish species
- Effects on survival, reproduction, or abundance for mammalian species

2.4.3.3 Measures of Ecosystem and Receptor Characteristics

Much better written and organized

Table 2.4.3.3-1 lists a set of measures of ecosystem and receptor characteristics that were used in the ecological risk assessment for the Coeur d'Alene Basin. Measures are used to evaluate risks to assessment endpoints. Measures of ecosystem and receptor characteristics are defined by USEPA (1998) as "measures that influence the behavior and location of ecological entities of the assessment endpoint, the distribution of a stressor, and the life-history characteristics of the assessment endpoint or its surrogate that may affect exposure in response to the stressor." Measures presented in Table 2.4.3.3-1 are organized by CSM unit, habitat type, and assessment endpoint. A brief linkage statement is provided for each measure that describes how the measure is associated with mining-related hazardous substance and the assessment endpoint.

The process that was used to select the measures of ecosystem and receptor characteristics shown in Table 2.4.3.3-1 followed three steps:

- Existing information on ecosystem and receptor characteristics that have been identified as physical or biological stressors within the Coeur d'Alene basin were reviewed.

- Ecologists familiar with the ecosystem were contacted directly for input into the identification of candidate measures.

- Potential measures were screened using three criteria to generate the list of measures shown in Table 2.4.3.3-1.

The information sources that were reviewed to identify a preliminary list of measures of ecosystem and receptor characteristics included the Ecological Restoration Workshops for the Coeur d'Alene River basin and current status CSM report (CH2M HILL 1998). The Ecological Restoration Workshops provided a comprehensive list of physical habitat factors that could influence the aquatic ecosystems and populations of aquatic organisms. Examples of some of the attributes that could affect the physical habitat include surface water flow fluctuations, effects of Post Falls dam, and stream channel bed substrate. The current status CSM report provided a conceptual site model that identified the physical stressors present in the upper watershed within the basin. Examples of some of the physical stressors include sediment loadings from tailings, altered erosion due to fire, and riparian encroachment due to housing and urban development. Some the attributes and stressors that were identified from these sources are potentially relevant for the CERCLA RI/FS for the basin, while others may not be relevant. Therefore, the comprehensive lists of measures provided in these documents were screened using the following three criteria to select candidate measures of ecosystem and receptor characteristics:

- The measure had to be directly or indirectly associated with mining-related hazardous substances; e.g., impacts of forest fires on stream water quality are not associated with mining-related chemical contamination and therefore were not selected as a measure.

- Methods had to be available to assess the ecological impact of the stressor; e.g., loss of large woody debris will affect stream habitat quality, but there may not be an acceptable method to quantitatively evaluate the impact of incremental losses of large woody debris on ability of the stream to provide suitable habitat for salmonids.

- Site-specific data on the measure had to be available; e.g., residual pool volume is considered an important limiting factor of the stream system in the upper watersheds, but little site-specific information is available to assess the current status of the residual pool volume.

The proportional contribution of mining-related hazardous substances to the risk associated with any of the measures of ecosystem and receptor characteristics will not be determined in this risk assessment. Many other factors may contribute to the degradation in any measure. For example, road construction and urban development have affected water temperature by removing much of the riparian habitat. **Section ???** and Appendix E identify many of the non-mining-related hazardous substance factors that affect the basin.

Measures of ecosystem and receptor characteristics were applied to CSM units for which data were available and preliminary evaluation showed the measure could be potentially limiting. For example, riparian habitat occurs in CSM Units 1, 2, 3, 4, and 5, but Table 2.4.3.3-1 shows that the habitat suitability index measure for the riparian habitat is only applied to CSM Units 1, 2, and 3. This is because data were not available to determine the habitat suitability index for riparian habitat in CSM Units 4 and 5. As another example, water temperature was believed to be a potential limiting factor to fish inhabiting streams in CSM Units 1 and 2 due to the loss of riparian vegetation. However, temperature was not believed to be limiting in the Coeur d'Alene River in CSM Unit 3 due to the ameliorating influence of the North Fork Coeur d'Alene River.

Measures of ecosystem and receptor characteristics were not identified for either the agricultural or upland habitats. The agricultural habitat is by nature physically highly modified through grazing and crop cultivation. Measures that define the physical habitat features do not apply to the agricultural habitat and therefore no measures of ecosystem and receptor characteristics where defined. The upland habitat is poorly characterized (i.e., the physical position of upland habitat areas as well as their current status is largely unknown) and therefore measures of ecosystem and receptor characteristics could not be defined.

The following sections briefly describe each measure of ecosystem and receptor characteristics. Additional information is contained in Appendix E.

2.4.3.3.1 Bank Stability. The bank stability measure describes the proportion of a given stream reach with banks that are not actively eroding. The data that describe this measure are typically intended to capture bank stability as provided by natural ecological functions (i.e., a stable stream morphology and bank stabilization functions provided by riparian vegetation, large woody debris (LWD) and other ecological features), versus bank stabilization provided by riprap or concrete dike systems.

Mining-related releases of hazardous substances affect bank stability throughout the South Fork Coeur d'Alene River and many of its tributaries through direct toxic effects on riparian zone vegetation (LeJeune and Cacela 1999). Floodplain and riparian zone vegetation has been killed by toxic effects from mining-related contaminants deposited in bank and floodplain sediments during high river flows. The loss of riparian zone and floodplain vegetation results in the subsequent loss of bank and floodplain stabilizing functions provided by root systems and LWD. The resulting bank instability has led to erosion of large inputs of fine-grained and coarse bedload material into stream ecosystems, destabilizing the stream channel and contributing to downstream effects on bank stability. The loss of topsoil, channel instability, and ongoing toxic effects hinder the re-establishment of riparian zone vegetation in some areas (LeJeune and Cacela 1999).

Loss of bank stability constitutes a risk to several identified receptors in the riverine habitats of CSM Units 1 and 2, specifically fish (bull trout, cutthroat trout, and sculpin) and the invertebrate community. Loss of bank stability results in ecosystem-level impacts through reductions in channel habitat complexity, specifically the loss of undercut bank habitats, and the filling of pools and other features. A complex suite of habitats is necessary to support the full range of age classes of various trout species and allow the completion of their life cycles (Cross and Everest 1995; Reiman and McIntyre 1993). Trout require a variety of habitat types throughout their life histories, including isolated pocket water with stable spawning gravels, off-channel and slow-water habitats for juvenile rearing, undercut bank habitat, riffle areas with adequate feeding cover, and deep pools occupied by the largest adults.

2.4.3.3.2 Substrate Composition and Mobility. The substrate composition and mobility measure describes the range of sediment grain sizes in the channel bed, their spatial distribution, and the mobility of these sediments under normal and high flow events. Data on several substrate characteristics are used to describe this measure. These characteristics fall into two discrete categories. Substrate composition characteristics describe predominant sediment types present (boulders, cobble, gravel, sand, etc.), and the proportion of fine sediments (expressed as a percent of average substrate composition). Substrate mobility describes the transport characteristics of fine-grained sediment and larger bedload through the stream channel. These characteristics include the scouring and/or deposition of large-grained sediments, deposition of fine-grained sediments, and brightness of bottom substrate (indicating mechanical abrasion).

High- to moderate-gradient stream channels typical of those found in CSM Units 1 and 2 are capable of transporting medium- to coarse-grained sediments under moderate to high flow events, and fine-grained sediments under almost all flow conditions. In stream systems of this type, natural small-scale patterns of disturbance are a feature of the landscape that contribute erosive inputs of bedload and fine sediments to the stream system. Typically, a state of dynamic equilibrium is established between erosive inputs of fine- to coarse-grained sediments, and the transport of these sediments through and out of the system. This results in a channel system with bedload that, while mobile, maintains a relatively high level of spatial and temporal stability. The habitat-forming and -maintaining processes driven by this state of dynamic equilibrium result in a diversity of sediment types with heterogeneous distribution in association with pools, riffles, LWD, stable undercut banks in association with extensive riparian vegetation, and other habitat features. These conditions contribute to the habitat complexity and diversity necessary to support a variety of aquatic species, including identified aquatic receptors in the Coeur d'Alene River basin (Bisson and Sedell 1982; Montgomery et al. 1999; URSG 1999).

Mining activities in the Coeur d'Alene River basin have resulted in large inputs of fine- and coarse-grained sediments into stream channels in CSM Units 1 and 2, exceeding the sediment transport capacity in various segments. These bedload materials are in various stages of transport through the riverine ecosystem and continue to contribute to channel and bedload instability. Mining-related hazardous waste has impacted bedload composition and mobility through direct toxic effects on riparian zone and floodplain vegetation, and the subsequent erosion of fine- and coarse-grained materials from destabilized streambanks and floodplains into the stream channel. Large inputs of bedload have contributed to destabilization of the stream channel in several CSM segments, with cascading effects on channel morphology and bank stability throughout stream systems in several areas. These effects are synergistic with and exacerbated by other forms of disturbance in the basin that contribute to substrate composition and bedload instability.

2.4.3.3.3 Water Temperature. The water temperature measure describes the maximum temperatures experienced in the riverine habitats of CSM Units 1 and 2 during warm weather. Stream temperature is an important factor in determining the suitability of habitats for aquatic species. Native species, including identified receptors in riverine habitats, are adapted to survive within a specific range of temperatures that are typically experienced in functional stream ecosystems. Temperatures in functional stream ecosystems are determined by a number of factors, including channel morphology, stream hydrology and connection to groundwater, and shading by riparian zone vegetation. Lower order streams in montane basins are typically well shaded by riparian vegetation, which may allow only 1 to 3 percent of available solar radiation to reach the surface. Physical factors controlling channel morphology in these stream systems typically result in narrow, deeper stream channels with less surface area for exposure to the atmosphere and solar radiation. This results in relatively cool summer temperatures in such systems. In higher order channels downstream, riparian zone shading is reduced and stream surfaces are exposed to more direct solar radiation and potential for higher stream temperatures. This is moderated again by channel morphology and by increased flow volumes (Naiman et al. 1992; Naiman and Decamps 1997).

2.4.3.3.4 Spatial Distribution of Stream Reaches with Acceptable Physical Conditions and Riparian Habitat with Acceptable Vegetation Community (Spatial Distribution and Connectivity). The spatial distribution and connectivity measure is an integrative measure that characterizes the effect of degradation of the previously described riverine and riparian habitat measures at landscape scales. The purpose this measure is to describe risks to aquatic and riparian receptors posed by the fragmentation of suitable habitat areas due, at least in part, to the effects of mining-related hazardous substances on physical habitat structure.

Releases of mining-related hazardous substances have resulted in alterations in riparian community structure and in some cases the loss of all riparian vegetation in some CSM segments. Similarly, the direct and secondary effects of these substances have resulted in extensive areas of degraded riverine habitat conditions and fragmentation of remaining relatively intact habitats. Numerous terrestrial and aquatic species, including identified receptors, are dependent on diverse riparian and riverine habitat structure for spawning, rearing, and migration. The degradation of riverine and riparian habitats and the fragmentation of these habitat types at meso and macro scales are interrelated and synergistic. The loss of ecological diversity and connectivity in these environments poses risks to aquatic and riparian receptors.

2.4.3.3.5 Riparian Vegetation Habitat Suitability Index. Mining-related hazardous substances have been shown to occur at phytotoxic levels in riparian soils within the Coeur d'Alene River basin and riparian vegetation within the basin has been negatively impacted by mining-related hazardous substances (LeJeune and Cacela 1999). As a measure of ecosystem and receptor characteristics, the riparian vegetation habitat suitability index will be used to evaluate the physical effects of the loss of riparian vegetation on the ability of the habitat to support wildlife species.

The habitat suitability index model used to evaluate the riparian vegetation was developed by Short (1984). This model is based on the principle that wildlife partition habitat resources along a vertical dimension and that this vertical dimension can be represented as habitat layers. Structurally complex habitats tend to provide more niche space and to accommodate more wildlife guilds and wildlife species.

2.4.3.3.6 Sediment Deposition Rate. Sediment deposition rates in aquatic systems vary over a wide range, depending on hydrologic conditions. Areas with negative sedimentation rates (i.e., areas of scouring or net loss of sediment) are not evaluated in this risk assessment. Areas with net accumulations of sediment can accumulate sediment at vastly different rates, from fractions of a millimeter per year to catastrophic, nearly instantaneous deposition of many feet of sediment, as occurred in the Toutle and Cowlitz Rivers in the immediate aftermath of the eruption of Mt. St. Helens in 1980 (Newcombe and Flagg 1983). While it is readily apparent why the instantaneous deposition of many feet of sediment would be injurious to aquatic species and their habitat, it is not immediately obvious why a much smaller increase—such as a few millimeters to a few centimeters per year increase—in natural deposition rates poses a threat to aquatic species.

There is an appreciable quantity of literature that documents the effects of increases in sediment deposition rate above normal levels for a given aquatic system on both aquatic biota and their habitat. Although none of the literature relating increases in deposition rate are specific to the Coeur d'Alene River basin, it does provide a sense of deposition rates that can have adverse impacts on aquatic systems.

2.4.3.3.7 Turbidity, Total Suspended Solids (TSS). Suspended solids are a natural component of all aquatic systems. As such, aquatic species over time have adapted to levels of suspended solids that naturally occur within their habitat. Concerns regarding elevated concentrations of suspended solids occur when concentrations exceed those that normally occur in an aquatic system. Suspended solids can have adverse effects on aquatic life both within the water column and after sedimentation of the solids to the bottom of the water body. This measure will discuss effects of suspended solids to aquatic biota within the water column.

Suspended solids levels in the St. Joe River, used as a reference stream for the main stem Coeur d'Alene River, range between 1 and 7 mg/L as measured by the U.S. Geological Survey. By contrast, suspended solids levels as high as 980 mg/L, and frequently in excess of 10 mg/L, have been observed in the main stem Coeur d'Alene River, whose watershed contains numerous areas where mining-associated activities have or are currently taking place. The concentrations of suspended solids in the Coeur d'Alene River are considerably higher than those measured in the St. Joe River reference stream, whose watershed does not contain areas of active mining. The increased cloudiness is due at least in part to mining-associated increases in the suspended solids content of the Coeur d'Alene River.

2.5 ECOLOGICAL CONCEPTUAL SITE MODEL

The CSM for the Coeur d'Alene River basin RI/FS is described in some detail in Section 2 of the RI report *[[Reference]]*. The parts of the CSM that are important for the EcoRA are the process models for each of the CSM segments as presented in the following subsections.

2.5.1 Process Models for Potential Ecological Exposures

The process models are a graphic presentation of our understanding of sources of metals, release mechanisms, pathways of exposure of ecological receptors, and transfer of metals (generally upstream to downstream) in the Coeur d'Alene River basin. The structures of the process models differ among the CSM Units as the number and types of sources vary, as do release mechanisms, habitats, and ecological receptors. The CSM Units were defined in large part based on similarities within CSM Units that could be represented by similar process diagrams. A generalized process diagram for CSM Unit 1 is shown as an example for the purpose of explanation of the elements of the process models (Figure 2.5.1-1).

The main components of the process model, e.g., inputs, source types, etc., are shown across the top of the diagram (Figure 2.5.1-1). Inputs are the sources of metals, water, and sediment entering the upper boundary. Primary source types are sources, or potential sources of mining waste, that are in locations where they were intentionally placed. Among the primary sources, what is meant by the cryptic names of several source types in Figure 2-5.1-1 is defined as follows:

- Mine workings: shafts and adits
- Other waste: Miscellaneous industrial waste including chemicals not derived from mining
- Waste rock: rock derived from mining activities (other than ore)
- Tailings: discarded fractions of ores
- Concentrates and other process wastes: ore concentrates, unprocessed ore, and other wastes related to mining
- Artificial fill: mining wastes intentionally placed as fill (e.g., for railroads, roadways and structures

Primary release mechanisms are release mechanisms that act on primary sources. The categories shown on Figure 2.5.1-1 are self-explanatory. Affected media and secondary sources are media where mining wastes now reside as a result of natural transport processes, e.g., erosion and deposition. The categories shown on Figure 2.5.1-1 are self-explanatory, except for alluvium. Alluvium in the context of the CSM means soils and other materials that have been transported by water to their present location, and usually are not covered by water. In the Coeur d'Alene River basin alluvium could consist entirely of naturally derived material or could be largely mining waste (e.g., water-transported tailings).

Secondary release mechanisms are release mechanisms that act on affected media and secondary sources. Except for chemical processes, the secondary release mechanisms shown on Figure 2.5-1-1 are self-explanatory. Chemical processes are the various processes that result in the chemical transformation, dissolution, and sometimes, precipitation of metals from secondary sources. The dissolution component is chemically similar to dissolution from primary sources. The understandings of geochemical processes in the Coeur d'Alene River basin developed as part of the CSM (Section 2.0 and Appendix I of the RI report) have been subsequently expanded and are described in detail in Section___. A summary of some of the chemical processes is provided in sections xx of the RI report *[[Reference]]*.

Exposure routes (Figure 2.5.1-1) are the pathways and processes by which humans and living natural resources (receptors) may be exposed to metals from mining waste. (Receptors are the humans and other organisms that may be exposed to mining wastes.) The last column of the example process model (Figure 2.5.1-1) lists the geographic linkages to downstream Segments or CSM Units, and provides a way to account for the transfer of metals and other materials. Transfer of metals is evaluated further in the discussions of mass loading for each Segment in Section__ of the RI report. There is also a component called "See Receptor Tables". The receptor tables are the tables of receptors for each CSM Unit that are in the CSM (Section 2.0 and Appendix I of the RI report). Those tables have now been consolidated into a single table in the EcoRA (Table__), where the reasons for the selection of particular representative receptors are explained. The process diagrams also contain a reference to an "issues statement." The issues statement is discussed further in Section 3.1.1.1 (below), but in general, is an attempt to account for the effects of factors other than mining wastes on the ecological receptors and assessment endpoints used in this EcoRA.

The pathways (connecting arrows) in the Preliminary Process Model were drawn with three different line weights to reflect the consensus of opinion during development of the CSM regarding the relative and absolute importance of the various pathways. In the generalized example shown in Figure 2.5.1-1 no pathways have been drawn with heavier line weights. This would represent the conditions in CSM segments with little ongoing release of mining wastes and little exposure of ecological receptors.

2.5.1.1 CSM Unit 1

All of the CSM watersheds and segments in CSM Unit 1 can be characterized by a diagram like Figure 2.5.1-1 (which is for relatively un-impacted areas). Impacted CSM segments within CSM Unit 1 are heavily affected by mining wastes and can generally be represented by Figure 2.5.1-2, which is the process diagram for Canyon Creek, Segment 5.

2.5.1.2 CSM Unit 2

CSM Unit 2 is comprised of four segments. The process diagrams for CSM unit 2 (for example, Figure 2.5.1-3) are similar to the process diagrams for CSM Unit 1. The example shown is from CSM Unit 2, Segment 1.

2.5.1.3 CSM Unit 3

CSM Unit 3 is the valley of the Coeur d'Alene River from Cataldo to Lake Coeur d'Alene. CSM Unit 3 differs from CSM Units 1 and 2 in that it lacks primary sources of mining waste, has a much lower hydraulic gradient, is subjected to extensive periodic flooding by the Coeur d'Alene River, has altered hydrology as a consequence of the operation of the Post Falls dam, and contains extensive areas of palustrine (wetland) and lacustrine (lake) habitat. CSM Unit 3 has been characterized by a single process diagram (Figure 2.5.1-4).

2.5.1.4 CSM Unit 4

CSM Unit 4 is Lake Coeur d'Alene. The process diagrams for Coeur d'Alene Lake (Section 2.0 and Appendix I of the RI report) are represented by Figure 2.5.1-5, which is the process diagram for Segment 2, the segment most affected by mining wastes.

2.5.1.5 CSM Unit 5

CSM Unit 5 is the Spokane River including Long Lake and the Spokane Arm of Lake Roosevelt. Most of CSM Unit 5 is represented by the process diagram shown in Figure 2.5.1-6, but impounded areas like Long Lake and the Spokane Arm of Lake Roosevelt are better represented by the process diagram for CSM Unit 4 (Figure 2.5.1-6).

2.5.2 Exposure Pathway Analysis

The potential routes of exposure describe the means by which chemicals are transferred from a contaminated medium to ecological receptors. The routes by which ecological receptors may be exposed to COPECs in the Coeur d'Alene River basin include the following:

- Aquatic plants - root uptake and direct contact with soil-sediment and surface water
- Fish - ingestion and direct contact with surface water
- Benthic invertebrates - ingestion and direct contact with soil-sediment or surface water
- Amphibians - direct contact with surface water
- Terrestrial plants - root uptake from soil-sediment
- Terrestrial invertebrates - ingestion and direct contact with soil-sediment.
- Microbial processes occurs through direct contact with soil-sediment
- Birds - ingestion of soil-sediment, surface water, and food (including potential bioaccumulation)
- Mammals - ingestion of soil-sediment, surface water, and food (including potential bioaccumulation)

Pathways deemed to be most important are shown as bolder lines on the process diagrams for the respective CSM Units. The exposure pathway analysis is also presented in Table 2.5.2-1. Some individual pathways have been combined with other pathways or have not been quantitatively evaluated because of a lack of available information for the exposure evaluation. For example, dermal and inhalation exposures for birds and mammals were not quantitatively addressed because they are considered relatively minor exposure pathways in relation to direct uptake and/or bioaccumulation through the food chain.

Aquatic plants can absorb chemicals from soil-sediment and surface water through their roots, leaves, or stems, and can store these chemicals in their tissues. Plants that have bioaccumulated chemicals may also serve as a source of exposure to receptors that eat the plants. Bio-film (microscopic plants and animals attached to surfaces underwater) may physically trap and contain metals-contaminated sediment in addition to that incorporated into plant and animal tissue.

Aquatic vertebrates, such as fish, may be exposed to chemicals in soil-sediment and surface water through ingestion, dermal contact, uptake through gills, and by feeding on contaminated plants, aquatic invertebrates, or smaller fish. Exposure may occur during feeding, spawning, or burrowing. Aquatic vertebrates also serve as a major route of food-chain transfer because they are prey for many semi-aquatic or terrestrial vertebrates, including reptiles, birds, and mammals.

Aquatic invertebrates may be exposed to chemicals in soil-sediment and surface water through ingestion and direct contact. They may ingest sediment, biofilm, and surface water during feeding or burrowing. They can also absorb chemicals from soil-sediment and surface water through their epidermis. Aquatic invertebrates also serve as a major route of food-chain transfer because they are prey for fish, birds, and mammals.

Amphibians may be exposed to chemicals in soil-sediment, and surface water, through ingestion, dermal contact, and by feeding on contaminated aquatic and terrestrial invertebrates. Exposure may occur during feeding, early development of eggs and larvae, or burrowing. Amphibians may also serve as a route of food chain transfer because they are prey for other vertebrates, including fish, reptiles, birds, and mammals.

Terrestrial plants can absorb and store chemicals from soil-sediment through their roots, leaves, or stems. Chemicals deposited in the leaves can result in visible signs of stress including necrosis (dead or dying patches) and chlorosis (alteration in chlorophyll causing changes in color). Plants that have bioaccumulated chemicals may also serve as a source of exposure to receptors that eat them.

Terrestrial invertebrates can absorb chemicals from soil-sediment through their epidermis or may ingest soil during feeding or burrowing. Invertebrates also serve as a major route of food-chain transfer because they are prey for many birds and mammals.

Microbial processes may be exposed to chemicals in soil-sediment through direct contact and breakdown processes. Microbial processes serve an important role in the decomposition of organic material and nutrient cycling. They convert nutrients to forms available for plant uptake and serve as a food source for higher trophic levels.

Birds and mammals may be exposed to chemicals in soil-sediment, surface water, and through incidental ingestion, dermal contact, inhalation of particulates, and food-chain transfer (ingesting contaminated prey or forage items). Ingestion of soil-sediment may result from several different behaviors. An animal may ingest soil-sediment during grooming, burrowing, or incidentally consuming plants, insects, or ground-dwelling invertebrates. Some animals, such as ground-feeding birds or deer, may also be exposed by deliberately ingesting soil-sediment to meet mineral requirements.

Exposure through the food chain is limited to chemicals that bioaccumulate. Food-chain transfer of COPECs to semi-aquatic or terrestrial vertebrates may occur when a plant or an animal (a primary receptor) that has bioaccumulated chemicals is subsequently ingested by a higher trophic level animal.

2.5.3 Identification of Representative Receptors

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It is not feasible to evaluate every plant, animal, and microbial species that may be present and potentially exposed within the Coeur d'Alene River basin. Consequently, receptors of high ecological or societal value or those believed to be representative of broader groups of organisms were selected for evaluation. Representative ecological receptors were selected based on current information on habitat types present and potential for exposure in the Coeur d'Alene River basin. Each receptor was chosen to represent a trophic category and particular feeding behaviors (e.g., diving birds versus shorebirds) that would represent different modes of exposure to COPECs. The following criteria were used to select potential receptors:

- The receptor does or could use habitats present in the basin.
- The receptor is important to either the structure or function of the ecosystem.
- The receptor is statutorily protected (i.e., threatened or endangered species, migratory birds) or is otherwise highly valued by society (i.e., species of cultural importance).
- The receptor is reflective and representative of the assessment endpoints for the Coeur d'Alene River basin.
- The receptor is known to be either sensitive or highly exposed to COPECs in the Coeur d'Alene River basin.

Where appropriate, the same receptors were used for more than one CSM unit to increase efficiency and consistency of the EcoRA and to allow for the comparative evaluation of CSM units. Table 2.5.3-1 summarizes the receptors identified by CSM unit and habitat type. The level of biological organization (e.g., individual, population, community or habitat/ecosystem) at which the receptor is to be evaluated also is presented.

SECTION 3.0 ANALYSIS

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3.1 EXPOSURE CHARACTERIZATION

3.~~1~~.1 Source Evaluation

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3.1.~~1~~.1 Sources of Stressors

Chemical stressors evaluated in this EcoRA are metals derived from mining wastes. Stressors occur as in-place wastes and as metals being released (mainly to water) from mining wastes. Sources that have released or continue to release hazardous substances to the Coeur d'Alene River basin include mining and mineral processing operations; waste rock, tailings dumps, and adits at former mine and mill sites; floodplains, river and lake beds and banks containing tailings and mixed tailings and alluvium; and eroding hillsides historically contaminated by smelter emissions. Source materials include waste rock, mill tailings, mixed tailings and alluvium, concentrates, mine drainage waters, smelter emissions, and flue dust. Types of releases include historical disposal of tailings to creeks, rivers, and floodplains, historical smelter emissions and ongoing releases of metals from waste deposits and sites where mine wastes now occur throughout the Coeur d'Alene River basin.

Non-mining related factors and actions (physical and biological stressors) also affect the receptors being evaluated in this EcoRA as reflected in part by the "issues statement" in the CSM (Section 2.0 of the RI report; ***Reference?***). The issues statement was derived from a draft (un-citable) report supplied by the U.S. Forest Service that addresses the effects of some physical non-mining-waste stressors on the hydrology and stability of streams in the Coeur d'Alene River basin, and is as follows:

> **Issue: Stream and river channels that shift and adjust at a rate and duration that significantly exceed the natural or historic ranges of variability are not capable of fully supporting beneficial uses.**
>
> Relevant conditions and processes that may define the issue:
>
> - Channels adjusting (rapidly changing) to recent in-channel adjustments rather than moving toward a more stable regime in response to an out-of-channel disturbance
> - Riparian area integrity compromised to the extent that stream and aquatic integrity are not fully supported
> - Channel integrity and dynamic equilibrium have been put at risk

- Frequency and magnitude of stream peak flows altered beyond the inherent equilibrium that channels have evolved
- Movement and deposition of bedload from upslope sources significantly modified
- Water quality limited stream segments (WQL) have been designated on streams that have been perceived to not fully support beneficial uses

Issue: Flood frequencies and magnitudes may be significantly increased and related flood damages are becoming more extensive.

Relevant conditions and processes that may define the issue:

- Some lands within a watershed generate and hold snowpacks that are significantly more sensitive to warm moist winter storms that can lead to rapid melt rates
- Vegetation treatment units and patterns and excavated travel facilities (roads, landings, skid trails, etc.) synchronize runoff or increase the rate of response of the watershed to rainfall and snowmelt events
- Stream channel and flood-prone area capacities and integrity are altered to the extent that they are no longer capable of handling peak flows without channel erosion or modifications or overbank flooding
- Developments and facilities within or adjacent to streams or their historic flood-prone areas are subject to damage or destruction of normal flood flow regimes

The CSM (Section 2.0 of the RI report) includes a figure, shown here as Figure 3.1.1-1, that illustrates how non-mining-related stressors could affect the receptors evaluated in this EcoRA.

3.1.1.2 Spatial and Temporal Distribution of Physical Stressors

3.1.1.2.1 Chemical. Chemical stressors are present at the locations of primary sources and also downgradient from the primary sources throughout the Coeur d'Alene River basin as a consequence of being transported by water and wind. Continuing releases of metals to water are occurring from primary and secondary sources ~~as described in Section of the RI report~~ ~~[[Reference?]]~~. Concentrations of metals in soil and sediment largely reflect past releases, while concentrations of metals in water largely reflect on-going releases.

Zinc is the metal with the largest on-going discharges in the Coeur d'Alene River basin, followed by lead and cadmium. The processes of releases and transport of zinc and cadmium are similar. Most zinc and cadmium are released and transported as dissolved metals, regardless of season, with very little attenuation in surface or ground waters in the Coeur d'Alene River basin. Using the amount of zinc discharged to Coeur d'Alene Lake as a reference, about half enters the South Fork as it passes through CSM Unit 2, Segment 2 (the Bunker Hill Superfund Site). Of the other half, approximately one-half (one-quarter of the total) comes from the Canyon and Ninemile Creek watersheds, with a large part of the remaining quarter coming from CSM Unit 2, Segment 1, the South Fork from Canyon Creek to Elizabeth Park. Loading of zinc and cadmium is greatest during periods of high flow, but concentrations are greatest during periods of low flow, when groundwater sources become relatively more important.

The Coeur d'Alene River variably gains and loses cadmium and zinc in CSM Unit 3, but amounts gained or lost are relatively small compared to the upper parts of the basin. Coeur d'Alene Lake is a sink for cadmium and zinc, which are lost from solution and settle to the lake bottom as water passes through the lake. However, at times, hydraulic conditions promote the rapid passage of metals through Coeur d'Alene Lake to the Spokane River. Both concentrations and loads of dissolved zinc and cadmium decrease progressively in the Spokane River, presumably as a result of dilution and precipitation.

A larger fraction (up to about 80 percent) of the lead released in the Coeur d'Alene River basin is released in particulate form. Lead releases are much higher during high flows than during low flows because of erosion, but concentrations of dissolved lead in surface waters are highest during low flows, when the relative proportions of dissolved lead are higher. In contrast to the pattern observed for zinc and cadmium, there are at times substantial releases of dissolved and particulate lead to the Coeur d'Alene River in CSM Unit 3. Coeur d'Alene Lake is a sink for both dissolved and particulate lead, but lead is also transported through the lake by certain hydraulic conditions. Both concentrations and loads of lead (dissolved and particulate) decrease with distance downstream in the Spokane River.

Figures to be developed when Mass-loading analysis (RI) is complete.

Figure 3-_ through Figure 3-_ Time/Variation of Mass Loading for COPECs in Surface Water for CSM Unit 1 (one figure per watershed)

Figure 3-_ through Figure 3-_ Time/Variation of Mass Loading for COPECs in Surface Water for CSM Unit 2 (one figure per watershed)

Figure 3-_ through Figure 3-_ Time/Variation of Mass Loading for COPECs in Surface Water for CSM Unit 3 (one figure per watershed)

Table 3-_ Mass Loading of COPECs in Surface Water in CSM Unit 3

3.1.1.2.2 Physical and Biological

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3.1.1.2.2.1 Bank Stability

Risks associated with bank instability were evaluated using different methodologies to reflect differences in the structure of available data. Risks in all segments in CSM Unit 1 as well as MidGradSeg01, MidGradSeg02, and MidgradSeg03 in CSM Unit 2 were evaluated using one data set and methodology. The available data set for MidGradSeg04 in CSM Unit 2 and all segments in CSM Unit 3 is substantially different from that for riverine habitat in other CSM segments. Bank stability has been inventoried in these latter segments (Wesche 1999), providing an excellent source of information for accurately describing the degree of bank instability present. However, a method for estimating risks to aquatic receptors in these segments from bank instability could not be developed due to a lack of suitable data on reference conditions for this type of stream system.

The primary sources of information used for the bank stability measure are the habitat surveys performed in support of the natural resource damage assessment (NRDA) process in the Coeur d'Alene River basin in 1996, and the Idaho Department of Environmental Quality (IDEQ) in 1998. These include surveys conducted using the EPA's Rapid Bioassessment Protocol (RBP) (Barbour et al. 1997), the stream reach inventory and channel stability evaluation (SRI) protocol used by the U.S. Forest Service (Pfankuch 1978), and the Beneficial Use Reconnaissance Project (BURP) habitat data scores developed by the IDEQ (1998, 1999). RBP scores for bank stability are defined in the summary of NRDA aquatic resources monitoring (Stratus 1999a). SRI scoring is defined by Pfankuch (1978). RBP and SRI scores for bank stability were assigned by R2 Resource Consultants during 1996 stream habitat surveys (R2 Resources 1997a). The raw rating scores for these surveys were provided by Stratus Consulting, Inc. (Stratus 1999b). In both the RBP and SRI methodologies, bank stability in a given stream reach is qualified as a proportion of overall reach length with bank stability characteristics typical for the region (e.g., 50 percent of reach length has adequate bank stability, 50 percent has visibly eroding stream banks). The BURP methodology characterizes bank stability as an absolute proportion of survey reach length. Raw data for the bank stability measure are provided in Tables F-3.1.1.2.2.1-1 and -2 in Appendix F.

The bank stability measure is derived from data sources describing the following characteristics:

- Bank stability: Based on qualitative surveys conducted by R2 Resources using the RBP, and rated using the RBP scoring criteria for this characteristic (Barbour et al. 1997; Stratus 1999a, 1999b)

- Landform slope: Based on qualitative surveys conducted by R2 Resources using the SRI protocol (Pfankuch 1978; Stratus 1999a, 1999b)

- Mass wasting hazard: Based on qualitative surveys conducted by R2 Resources using the SRI protocol (Pfankuch 1978; Stratus 1999a, 1999b)

- Based on qualitative surveys conducted by R2 Resources using the SRI protocol (Pfankuch 1978; Stratus 1999a, 1999b)

- Vegetative bank protection: Based on qualitative surveys conducted by R2 Resources using the SRI protocol (Pfankuch 1978; Stratus 1999a, 1999b)

- Bank cutting: Based on qualitative surveys conducted by R2 Resources using the SRI protocol (Pfankuch 1978; Stratus 1999a, 1999b)

- Lower bank stability: Based on qualitative surveys conducted by the BURP program (IDEQ 1998, 1999)

An expanded discussion of data sources and methods for evaluating the bank stability measure, and characteristic scores for reference streams for CSM Units 1 and 2, are presented in Appendix E. For a given CSM segment or reference area, an estimate of overall bank stability conditions was qualitatively derived from the combination of scores for all surveyed bank stability characteristics. These scores were compared to risk criteria defined using the RBP scoring protocol for bank stability, modified by conditions found in suitable reference streams for CSM Units 1 and 2, as described in Section 3.2.2.1.

It is important to note that in general, the intent of the qualitative bank stability characteristic is to provide an estimate of the degree of bank stability provided by natural ecosystem functions. However, given bank stability characteristics may reflect unnatural conditions, including channelization and removal of erodable materials from floodplains and riparian areas, which leaves only large, relatively stable substrate. In such areas, high scores for bank stability may not necessarily equate to ecologically desirable conditions.

The RBP and SRI surveys were conducted on stream reaches representative of selected CSM segments throughout CSM Units 1 and 2, and on reference streams in the North Fork Coeur d'Alene River, St. Joe River, and St. Regis River basins. These reference streams were selected to be representative of conditions in the absence of mining-related influences (Hagler Bailley 1998; R2 Resources 1997a; Stratus 1999c). For the risk assessment, bank stability ratings for tributary streams in the Salmon River basin are also used for reference values. The Salmon River basin lies within the same ecological region (Northern Rocky Mountains) as the Coeur d'Alene River basin and is representative of conditions in systems with limited levels of anthropogenic disturbance. These ratings were collected using RBP protocols (Bauer and Ralph 1999; Omernick and Gallant 1986).

RBP and SRI rating scales for bank stability and bank stability scores for reference area streams are presented in Table F-3.1.1.2.2.1-2 in Appendix F.

3.1.1.2.2.2 Substrate Composition and Mobility

The primary sources of information used for the substrate composition and mobility measure are the habitat surveys performed in support of the natural resource damage assessment (NRDA) process in the Coeur d'Alene River basin in 1996 and data collected by the Idaho Department of Environmental Quality (IDEQ) in 1998. These include surveys conducted using the stream reach inventory and channel stability evaluation (SRI) protocol used by the U.S. Forest Service (Pfankuch 1978), the EPA's Rapid Bioassessment Protocol (RBP) (Barbour et al. 1997) conducted under low flow conditions in September 1996 (Reiser 1999), a spawning gravel characterization conducted by R2 Resource Consultants (Stratus 1999a and 1999b), and the Beneficial Use Reconnaissance Project (BURP) habitat surveys conducted by IDEQ (1998, 1999).

The substrate composition and mobility measure is derived from several data sources that describe the following physical characteristics:

- Substrate percent fines: Based on qualitative and quantitative surveys conducted by R2 Resources and the BURP program (IDEQ 1998, 1999; Stratus 1999a, 1999b) and rated using literature values, then adjusted on the basis of reference area data for this characteristic (Hickman and Raleigh 1982; Spence et al. 1996).

- Substrate embeddedness: Based on qualitative surveys conducted by R2 Resources using the RBP and SRI protocols, and rated using RBP scoring criteria for this characteristic (Barbour et al. 1997; Stratus 1999a, 1999b)
- Substrate distribution and percent stable: Based on qualitative surveys conducted by R2 Resources using the SRI protocol and rated using the SRI scoring criteria for this characteristic (Pfankuch 1978; Stratus 1999a, 1999b)
- Bottom scouring and deposition: Based on qualitative surveys conducted by R2 Resources using the RBP protocol and rated using the RBP scoring criteria for this characteristic (Barbour et al. 1997; Stratus 1999a, 1999b)
- Scouring and deposition: Based on qualitative surveys conducted by R2 Resources using the SRI protocol and rated using the SRI scoring criteria for this characteristic (Pfankuch 1978; Stratus 1999a, 1999b)
- Deposition of fines: Based on qualitative surveys conducted by R2 Resources using the SRI protocol and rated using the SRI scoring criteria for this characteristic (Pfankuch 1978; Stratus 1999a, 1999b)
- Brightness: Based on qualitative surveys conducted by R2 Resources using the SRI protocol and rated using the SRI scoring criteria for this characteristic (Pfankuch 1978; Stratus 1999a, 1999b)

An expanded discussion of data sources and methods for evaluating the substrate composition and mobility measure and characteristic scores for reference streams for CSM Units 1 and 2 is presented in Appendix E.

The data used to evaluate the substrate composition and mobility measure have limitations that must be considered when interpreting the results of the risk estimation. These limitations are discussed in Section 3.2.2.2.

3.1.1.2.2.3 Water Temperature

Continuous surface water temperature monitoring data were collected by R2 Resource Consultants in 1994, 1995, and 1996 at selected locations in the South Fork Coeur d'Alene River and its tributaries including Canyon Creek, Ninemile Creek, Placer Creek, Lake Gulch, Moon Creek, Big Creek, and Pine Creek; the main stem Coeur d'Alene River; the St. Joe River and its tributaries; the St. Regis River; and selected tributaries to the North Fork Coeur d'Alene River including Prichard Creek and Beaver Creek as part of the natural resource damage assessment (NRDA) process (Stratus 1999a, 1999b). In tributary watersheds, temperature monitoring locations were typically placed in downstream segments near a main stem confluence. In the main stem areas of the South Fork Coeur d'Alene River and reference streams, the monitoring locations were distributed at several locations, from near the headwaters to the downstream areas of the watershed. Reference streams identified for CSM Unit 2 include the moderate-gradient reaches of the St. Regis River, the St. Joe River, and moderate-gradient tributaries of the North Fork Coeur d'Alene River (e.g., the lower Little North Fork Coeur d'Alene River) (Hagler Bailley 1998; Stratus 1999a, 1999b). Reference streams for CSM Unit 1 and 2 segments are identified in Appendix 3.1.1.2.2.3-1. Temperature monitoring locations in assessment segments in CSM Units 1 and 2 are illustrated in Figure 3.1.1.2.2.3-1.

The data provided for this analysis were summarized to show the high and average temperatures at a given location by month (Stratus 1999a, 1999b). This data structure does not allow for evaluation of the length of time which temperatures exceed critical thresholds, or the degree of diurnal temperature fluctuation that could reduce thermal stress on aquatic receptors. The 1995 and 1996 temperature data include monthly average and instantaneous maximum temperatures, the most useful information being the instantaneous maximum. The 1994 temperature data included only a limited number of locations and were summarized to identify only the instantaneous maximum temperature recorded from July to October of that year. The instantaneous maximum temperatures observed during the 1995 and 1996 monitoring years are used to evaluate the temperature measure. The 1994 data set includes only two reference streams and is otherwise limited due to its level of summarization. However, because the highest recorded stream temperatures occurred in 1994, these data are used where applicable in the risk characterization. Data used to evaluate the temperature measure in CSM Units 1 and 2 are provided in Tables F-3.1.1.2.2.3-1 to -6 in Appendix F.

3.1.1.2.2.4 [[Section deleted]]

3.1.1.2.2.5 Habitat Suitability Index Model for the Riparian Habitat

A habitat suitability index (HSI) model of the vegetative community in the riparian habitat was developed as part of the natural resource damage assessment for the Coeur d'Alene River basin of Idaho (Hagler Bailly 1995). Information generated from that study forms the basis of this element of the risk assessment.

Short (1984) developed a HSI model for terrestrial habitats that utilizes the "layers of habitat" concept to provide an assessment of the ability of the habitat to support nonfish vertebrate wildlife. This model is based on the principle that wildlife partition habitat resources along a vertical dimension and that this vertical dimension can be represented as habitat layers. Structurally complex habitats tend to provide more niche space and to accommodate more wildlife guilds and wildlife species. The "layers of habitat" HSI model provides a low-resolution estimate of the relative quantity of habitat that is available for the total vertebrate wildlife community that could potentially occur there (Short 1984).

The HSI values used in this risk assessment were calculated as shown in Equation 1.

$$HSI = [l\sum_{i=1}^{l} A_i]/[n\sum_{j=1}^{n} A_j] \qquad \text{(Eq.1)}$$

Where:

l = the actual number of habitat layers present within an assessment site

A_i = the actual percent areal coverage of layer of habitat i within an assessment site

n = the maximum number of habitat layers present in a site

A_j = the maximum percent areal coverage of layer of habitat j within a site

At each of 107 riparian sampling sites within the basin (Figure 3.1.1.2.2.10-1), vegetation community structure and composition were quantified using visual estimation techniques. Within a 10-meter radius of the midpoint of each sampling site, the following characteristics were visually estimated:

- Most prevalent cover type (that which would shade the greatest proportion of the ground surface if the sun were directly overhead)
- Habitat layers present
- Approximate areal coverage of each habitat layer

Cover types and habitat layer criteria are described in Table 3.1.1.2.2.5-1. All five habitat layers described in the table were used to determine the number of habitat layers present within a site. The areal coverage for the tree bole habitat layer was classified as either present or not present.

The optimum habitat (HSI = 1.00) for sites in CSM Units 1 and 2 was defined as the habitat at Little North Fork River site 3 (NF03). For sites in CSM Unit 3, the optimum habitat was defined as the habitat at Lower Coeur d'Alene River site 11 (LC11).

Raw data used in the HSI analysis are presented in Table F-3.1.1.2.2.5-1 in Appendix F. Sampling sites were grouped by segment and descriptive statistics were calculated for each assessment segment and the pooled reference area, as described in Section 3.2.2.5 (Table 3.1.1.2.2.5-2). HSI data were limited to segments located along Canyon Creek, Ninemile Creek, the South Fork Coeur d'Alene River, and the main stem Coeur d'Alene River.

3.1.1.2.2.6 Suspended Solids

All suspended solids data used in the ecological risk assessment were collected by the U.S. Geological Survey (USGS 1994, 1995, 1996, 1997, and 1998) and are presented in Appendix F. Data are available from the following locations on the main stem Coeur d'Alene River: Coeur d'Alene River at Cataldo (LCDRSeg01), Coeur d'Alene River below Latour Creek (LCDRSeg01), Coeur d'Alene River at Rose Lake (LCDRSeg02), Coeur d'Alene River below Rose Creek (LCDRSeg02), Coeur d'Alene River above Killarney Lake outlet (LCDRSeg03), Coeur d'Alene River below Blue Lake (LCDRSeg04), Coeur d'Alene River at Harrison (LCDRSeg05), Coeur d'Alene River at Harrison Bridge (LCDRSeg06), the Spokane River at Post Falls dam (SpokaneRSeg01), and a reference area on the St. Joe River at Calder, Idaho.

Data collected between October 1993 (the beginning of USGS water year 1994) and June 1999 were used in the risk assessment. The data used are believed to provide a complete description of the range of suspended solids in the main stem Coeur d'Alene River from low flow to severe flood conditions. Older suspended solids data were not used to evaluate risks to aquatic biota. The available measured suspended solids data from the main stem Coeur d'Alene River and the Spokane River are somewhat patchy in nature, both spatially and temporally. Suspended solids data are also available from a USGS gaging station on the St. Joe River at Calder against which to rate suspended solids in the lower Coeur d'Alene River. Data for water years 1996 through 1998 indicate that the maximum observed suspended solids in the St. Joe River during the last 3 years was 7 mg/L (range of 1 to 7 mg/L; average of 3 mg/L).

Among the available suspended solids data are samples collected during February 8 through 10, 1996. This period was later determined by USGS to be the second largest flood event observed on the Coeur d'Alene River since USGS began monitoring the main stem Coeur d'Alene River. The suspended solids samples collected during this flood serve to illustrate the highest suspended solids concentrations (76 to 980 mg/L) likely to be observed in the river. Six of the eight suspended solids samples collected during this time (two of three samples from Cataldo, two of three samples from the Coeur d'Alene River at Rose Lake, and both samples from Harrison) contained between 260 and 980 mg/L. These samples, although not typical of the suspended solids concentrations found in the Coeur d'Alene River under lower discharge condition, serve to bound the upper end of the suspended solids concentrations and short-term risks from suspended solids within CSM Unit 3.

The raw suspended solids data used in this evaluation are provided in Table F-3.1.1.2.2.6-2 in Appendix F. Summary statistics (number of samples, minimum, median, maximum) for the measured suspended solids concentrations within each segment for which data exist are presented in Table 3.1.1.2.2.6-1. These data are presented to permit an evaluation of the range of risks to receptors posed by suspended solids.

3.1.1.2.2.7 [[Section deleted]]

3.1.1.2.2.8 Sediment Deposition Rate

Discharge of tailings into the stream channel and loss of riparian habitat in the upper Coeur d'Alene River basin (CSM Units 1 and 2) have resulted in increased sediment loading in the basin. Sediment is transported downstream to deposit in the more quiescent areas of CSM Unit 3, Coeur d'Alene Lake (CSM Unit 4), and the Spokane River (CSM Unit 5).

Sediment deposition rate data were obtained from sediment core data collected from several different studies performed within the Coeur d'Alene River basin. Sediment core data were available for several segments within CSM Unit 3 and all three segments within CSM Unit 4 (Coeur d'Alene Lake). No sediment core data were available for CSM Unit 5. Horowitz et al. (1993) attempted to collect sediment cores from the 6-kilometer reach of the Spokane River immediately downstream of where Coeur d'Alene Lake discharges into the Spokane River. They were only able to recover an occasional rounded cobble, which they took as indication that the river bottom was armored immediately downstream of Coeur d'Alene Lake.

Most sediment core sampling locations where sediment deposition rate information is available are shown in Figure 3.1.1.2.2.8-1. Core samples from Coeur d'Alene Lake south of the mouth of the Coeur d'Alene River (i.e. the St. Joe arm of the lake) used to estimate deposition rates were analyzed by Horowitz et al. (1993, 1995). They analyzed multiple core samples to obtain sediment deposition rate estimates for the St. Joe arm. However, the specific cores used during preparation of the deposition rate estimate were not identified by Horowitz et al. (1993, 1995), and therefore could not be shown on Figure 3.1.1.2.2.8-1. The sediment deposition rate data and data sources are presented in Table 3.1.1.2.2.8-1.

3.1.1.2.2.9 Spatial Distribution and Connectivity

As discussed in Section 2.4.3.3, a growing base of literature describes the detrimental effects of the degradation of habitat and the loss of connectivity between areas of suitable habitat quality on aquatic and terrestrial species. Salmonid metapopulations, including bull trout and cutthroat trout, for example, are particularly vulnerable to habitat fragmentation. Aquatic macroinvertebrate and amphibian species are less vulnerable to these impacts at population levels; however, the fragmentation of habitats and chronic habitat disturbance associated with human activities can adversely impact these species.

The spatial distribution and connectivity measure is an integrative measure that describes whether CSM segments in the Coeur d'Alene River basin have acceptable or degraded physical conditions. It is based on the spatial distribution of stream reaches and riparian habitats with acceptable physical conditions. This measure provides a broader perspective on the results of the risk estimation for the other habitat measures for the riverine and riparian habitats. This measure of effect for spatial distribution and connectivity in riverine and riparian habitats is derived from the integration of the following information:

- Riverine measures of ecosystem and receptor characteristics, including bank stability, substrate composition and mobility, and temperature
- Riparian measures of ecosystem and receptor characteristics, including the riparian habitat suitability index and riparian vegetation condition
- Qualitative evaluation of habitat conditions observed in aerial photographs and correlation with available habitat data
- Qualitative evaluation of conditions observed during site visits

The measures of ecosystem and receptor characteristics used to characterize the measure of effect for spatial distribution and connectivity are described in Sections 4.1.2.2 and 4.1.2.4. The measure of effect for riparian and riverine spatial distribution and connectivity is derived from the distribution of degraded conditions observed or indicated by available data and information. Reduced connectivity of favorable habitats is indicative of habitat fragmentation. The impacts on aquatic and riparian habitat fragmentation are well documented (Section 2.4.3.3), and indicate that such fragmentation can contribute to risks to identified receptors in these habitats in the Coeur d'Alene River basin.

3.1.1.2.2.10 Riparian Vegetation

A summary of the data sources used in the riparian vegetation analyses is presented in this subsection. A comprehensive description of data sources is contained in Appendix E. The assessment of riparian vegetation is largely based upon information generated as part of the Coeur d'Alene River basin natural resource damage assessment (NRDA). Specific information sources used in this assessment include:

- Riparian resources NRDA reports (Hagler Bailly 1995; Stratus 1999; LeJeune and Cacela 1999) and a spreadsheet of riparian vegetation data (Stratus 2000a)
- A modified Bureau of Land Management (BLM) vegetation cover map for the Coeur d'Alene River basin (Stratus 2000b)
- Expert report on the aquatic ecosystem of the South Fork Coeur d'Alene River and main stem Coeur d'Alene River (Wesche 1999)
- Observations from a November 1999 field visit conducted by ecologists from URS Greiner, Inc.

As part of the NRDA (Hagler Bailly 1995; Stratus 1999; LeJeune and Cacela 1999), soil samples were collected and riparian vegetative characteristics were measured at 107 sampling sites located on the floodplains of Canyon Creek, Ninemile Creek, South Fork Coeur d'Alene River, and the lower Coeur d'Alene River (Figure 3.1.1.2.2.10-1). This sampling area covers portions of CSM Units 1 and 2, and most of CSM Unit 3.

Riparian habitat reference areas were selected based on similarity to the assessment areas in terms of major environmental factors that affect plant growth and vegetation community development, but are not exposed to mining-related hazardous substances (Hagler Bailly 1995; Stratus 1999; LeJeune and Cacela 1999). Where possible, reference areas were located upgradient of assessment areas. When a suitable upstream reference area was not available, a reference area was identified based on proximity to the assessment area, comparable elevation, and comparable valley orientation.

The risk assessment for riparian vegetation was performed on a CSM segment level. Descriptive statistics for each segment and the pooled reference area are presented in Tables 3.1.1.2.2.10-1 (vegetative characteristics) and 3.1.1.2.2.10-2 (soil characteristics). not in figures volume

The BLM produced a vegetation cover map for the Coeur d'Alene River basin in 1999. The "barren area" cover class originally created by BLM included tailings piles, areas physically disturbed by human activity (e.g., gravel roads), and other areas devoid of vegetation. Stratus Consulting, Inc., modified the original BLM vegetative cover map to distinguish barren areas that were associated with tailings piles and physical human disturbance from other bare areas (Stratus 2000b). This risk assessment uses the modified barren areas cover class data. The percentage of the floodplain area in each CSM segment that is associated with each of four cover types (including "barren area") was calculated in ArcView® and the results are shown in Table 3.1.1.2.2.10-3.

Wesche (1999) conducted a habitat survey of the main stem Coeur d'Alene River and the South Fork Coeur d'Alene River including Ninemile and Canyon Creeks in the summer of 1999. As part of that habitat survey, stream bank vegetation was assessed. The data provided by Wesche (1999) are not comparable to the NRDA data (Hagler Bailly 1995), but were used to augment the interpretation of the NRDA data.

Finally, a field visit was conducted by URS Greiner, Inc., ecologists in November 1999. Observations made during that field visit were used to confirm results based on the NRDA data (Hagler Bailly 1995) and to fill in gaps in spatial coverage as required.

3.1.2 Exposure Estimation

Exposure is defined as the co-occurrence of a receptor and a stressor in both space and time. For risk to be present, there must be exposure. Therefore, to estimate risk, the exposure experienced by receptors must be described. Exposure estimation methods and models, pathways, and assumptions for each receptor are described in this section.

The exposure that an animal experience s may be characterized as either external to the animal (e.g., immersion in or oral ingestion of contaminated media) or internal to the animal (e.g., COPEC concentrations within the receptor animal's tissues). In this assessment, both internal and external estimates of exposure are presented insofar as available data support.

Isn't oral ingestion internal to an animal?

3.1.2.1 Aquatic Plants

Aquatic organisms are exposed to metals in water as a consequence of living in a contaminated medium. Uptake of metals can be through the skin (dermal), through the gills, or through the diet, including ingestion of contaminated food, water, and possibly sediment. Most information on effects of contaminants on aquatic organisms has been obtained in experiments where the effects of exposure to contaminants have been measured as concentrations of contaminants in water absent significant exposure through food ingestion, and effects reported as a function of the concentrations of contaminants in water. For metals, EPA and the State of Idaho have determined that most adverse effects are caused by the dissolved fraction, so the exposure concentrations described below are those of dissolved metals. Some studies have estimated exposure and effects from ingestion of contaminated food, but information on integrated exposures is rare.

In contrast to water, most effects of exposure to contaminated sediments have been measured as integrated exposures to sediment, associated pore water, and contaminated food that may be present in the contaminated sediment. However, effects are generally reported as concentrations contaminants in sediment. The interpretation of effects of metals in sediment on aquatic organisms is complicated by the fact that physical and chemical properties of sediment and metals can alter the bioavailability, and thus the toxicity, of the metals. Nevertheless, exposure concentrations are reported here as total metals in sediment.

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There are two 3.1.2.1. Aquatic plants - but text refers to aquatic organisms

3.1.2.1 Internal Exposure

Internal exposure data for fish consist of both measured and modeled concentrations of COPECs in liver and kidney tissues. Measured data were obtained from Funk et al. (1973) and from the USFWS Reconnaissance dataset. These data are summarized in Table 3.1.2.3.2-1.

In a study of fate and transport of metals in biota in the Coeur d'Alene River basin, Farag et al. (1995 and 1998) measured concentrations of cadmium, copper, lead, and zinc in sediment and kidneys of trout from four locations. These data are summarized in Figure 3.1.2.3.2-1. Loglinear regression models were fitted to these data (Table 3.1.2.3.2-2). These regression models were then applied to measured concentrations of cadmium, copper, lead, and zinc in sediment to estimate metal concentrations in kidneys of trout in each CSM unit, segment, and aquatic habitat type in the Coeur d'Alene River basin. Summary statistics for estimated concentrations of metals in kidneys of trout are presented in Table 3.1.2.3.2-3.

Summary statistics for estimated dissolved metals concentrations for the COPECs in surface water are presented in Table 3.1.2.1-1. These summary statistics are based on surface water samples collected from rivers, lakes, and wetlands and are grouped by CSM unit and segment. For comparison, the 95th percentile of estimated background concentrations for the entire South Fork Coeur d'Alene River basin are also presented (see Section 2.3.2). A complete listing of the dissolved metals concentration data used to generate these summary statistics is included in Appendix H.

Summary statistics for estimated metals concentrations for COPEC in sediment are presented in Table 3.1.2.1-2. These summary statistics are based on sediment samples collected from lakes, rivers, and wetlands and are grouped by CSM unit and segment. For comparison, the sediment PRG is also presented (see Section 2.3.2). A complete listing of the sediment metals concentration data used to generate these summary statistics is included in Appendix H.

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3.1.2.1 Internal Exposure

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3.1.2.3 Fish (Section deleted) — why?

3.1.2.4 Amphibians

Amphibians can be exposed to COPECs in sediment and surface water. They are especially susceptible to adverse exposures during the egg and larval stages due to the porous eggs and skin. Most amphibians also burrow into the sediment during winter and periods of excessive heat and/or drought as they are dependent on the sediment and overlying waters to keep their skin moist. Amphibians are also important in the food-web because they serve as prey for larger species such as birds and small mammals.

3.1.2.5 Soil-Associated Biota

Soil-associated biota that can be exposed to COPECs in soil include terrestrial plants, soil invertebrates, and microbial processes. Terrestrial plants can absorb chemicals via root uptake from soil. Many chemicals absorbed by plants are deposited in the leaves. In addition to direct toxicity to the plant, chemicals that bioaccumulate within plant tissues (e.g., leaves) may result in food-chain transfer of chemicals to higher trophic level organisms.

Soil invertebrates can absorb chemicals through their epidermis and can accidentally or purposefully ingest soil during feeding or burrowing. Some soil-dwelling invertebrates are especially prone to exposure to chemicals present in soils because they consume the organic materials from within the soil (e.g., earthworms). Soil invertebrates also serve as a major route of food-chain transfer, because they are prey for some birds and small mammals.

Microbial processes include a large variety of highly adaptable organisms. Effects of chemical contaminants may change the community structure without impacting the functional ability of the community. Primary community functions include carbon mineralization, nitrogen transformation, and enzyme activities.

3.1.2.6 Birds and Mammals

3.1.2.6.1 External Exposure

Whereas external exposure experienced by fish, sediment-and-soil-biota are expressed as a function of the medium in which they live (i.e., water, sediment, or soil), birds and mammals experience external exposure through multiple pathways. To address this multiple pathway exposure, modeling is required.

3.1.2.6.1.1 Model

The general form of the model used to estimate external exposure of birds and mammals to COPECs was:

$$E_t = E_o + E_d + E_i$$

Where:

E_t = the total chemical exposure experienced by wildlife

E_o, E_d, and E_i = oral, dermal, and inhalation exposure, respectively

Oral exposure occurs through the consumption of contaminated food, water, or soil-sediment. Dermal exposure occurs when contaminants are absorbed directly through the skin. Inhalation exposure occurs when volatile compounds or fine particulates are inhaled into the lungs. Although methods are available for assessing dermal exposure to humans (USEPA 1992), data necessary to estimate dermal exposure are generally not available for wildlife (USEPA 1993a). Similarly, methods and data necessary to estimate wildlife inhalation exposure are poorly developed or generally not available (USEPA 1993b). Therefore, for the purposes of this assessment, both dermal and inhalation exposure are assumed to be negligible. As a consequence, most exposure must be attributed to the oral exposure pathway. By replacing E_o with a generalized exposure model modified from Suter et al. (2000), the previous equation was rewritten as follows:

$$E_j = \left[Soil_j \times P_s \times FIR\right] + \left[\sum_{i=1}^{N} B_{ij} \times P_i \times FIR\right] + \left[Water_j \times WIR\right]$$

Where:

E_j = total exposure (mg/kg/d)

$Soil_j$ = concentration of chemical (j) in soil (mg/kg)

P_s = soil ingestion rate as proportion of diet

FIR = species-specific food ingestion rate (kg food/kg body weight/d)

B_{ij} = concentration of chemical (j) in biota type (i) (mg/kg)

P_i = proportion of biota type (i) in diet

$Water_j$ = concentration of chemical (j) in water (mg/L)

WIR = species-specific water ingestion rate (L/kg body weight/d)

3.1.2.6.1.2 Life History Parameters

Birds and mammals can be exposed to chemicals in sediment/soil or surface water from several different behaviors. Animals can inadvertently or purposefully ingest sediment/soil while grooming, burrowing, or feeding. Surface water can be ingested as a drinking water source or during bathing or grooming activities. Dermal contact with sediment/soil or surface water is considered to be a secondary route of exposure for birds and mammals. Dermal contact is of concern primarily with organic chemicals that are lipophilic (i.e., have an affinity for fats) and can cross the epidermis of the exposed organism.

Species accounts for each representative species were presented in Section 2.5.3 (Identification of Representative Species). The specific life history parameters required to estimate exposure of each receptor to COPECs were obtained from the literature and are presented in Table 3.1.2.6.1.2-1.

3.1.2.6.1.3 Bioaccumulation Models

A critical component for the estimation of external exposure of birds and mammals is measurements of concentrations of COPECs in wildlife foods. The most preferred data are direct measurements of concentrations in samples collected from the field. Available data for concentrations of COPECs in wildlife foods collected from within the Coeur d'Alene River basin are summarized in Table 2.3.1.4-2. Not all food types consumed by the selected avian and mammalian receptors, nor all areas within the Coeur d'Alene River basin, are represented. To allow estimation of exposure to COPECs for all receptors and locations within the Coeur d'Alene River basin, estimation of concentrations of COPECs in wildlife foods was necessary. Bioaccumulation models for each wildlife food type were either located from published literature or developed based on site-specific data. These bioaccumulation models are summarized below.

Aquatic Plants

Site-specific data for bioaccumulation of COPECs by aquatic plants were available from three sources: Campbell et al. (1998), Kreiger (1990), and the USFWS Reconnaissance dataset. Campbell et al. (1998) and Kreiger (1990) present data for bioaccumulation by water potatoes, while bioaccumulation data for *Equisetum* spp. are presented in the USFWS dataset. Median COPEC concentrations in sediment and unpeeled water potatoes from 14 wetlands in the Coeur d'Alene and St. Joe basins were pooled with the co-located sediment and plant samples reported in Kreiger (1990) and USFWS dataset. Log-linear regression models were fitted to this combined dataset. Scatterplots of the relationships between COPEC concentrations in sediment and aquatic plant tissues are presented in Figure 3.1.2.6.1.3-1. Significant positive regression models were obtained for each COPEC (Table 3.1.2.6.1.3-1). Because site-specific data were only available for cadmium, lead and zinc, models for arsenic, copper, and mercury were obtained from the published literature. Bioaccumulation models for aquatic plants were not located, so models for terrestrial plants were assumed to be suitable (Table 3.1.2.6.1.3-1).

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Fish

Site-specific sediment-to-whole fish (yellow perch) bioaccumulation data were available from Farag et al. (1995 and 1998). Log-linear regression models were fitted to these data. Scatterplots of the relationships between COPEC concentrations in sediment and whole yellow perch are presented in Figure 3.1.2.6.1.3-2. Significant positive regression models were obtained for all COPECs except arsenic and copper (Table 3.1.2.6.1.3-2). To address bioaccumulation of arsenic and copper, biota-sediment accumulation factors (BSAFs; tissue concentration/sediment concentration) were calculated. Median (plus minimum, 90th percentile, and maximum) BSAFs for arsenic and copper were 0.007 (0.0002, 0.181, and 0.779) and 0.103 (0.044, 0.343, and 0.386), respectively.

Aquatic Invertebrates

Site-specific sediment-to-aquatic invertebrate bioaccumulation data were available from Farag et al. (1995 and 1998). Log-linear regression models were fitted to these data. Scatterplots of the relationships between COPEC concentrations in sediment and aquatic invertebrates are presented in Figure 3.1.2.6.1.3-3. Significant positive regression models were obtained for all COPECs (Table 3.1.2.6.1.3-3).

Amphibians

Bioaccumulation by amphibians was estimated using a combination of site-specific and non-site-specific data (Table 3.1.2.6.1.3-4). Data for both larval and adult lifestages were pooled and log-linear regression models were fitted to these data. Scatterplots of the relationships between COPEC concentrations in sediment and amphibians are presented in Figure 3.1.2.6.1.3-4. Despite small sample sizes for some COPECs, significant positive regression models were obtained for all COPECs for which data were available (Table 3.1.2.6.1.3-5). For those COPECs for which bioaccumulation data for amphibians were lacking (i.e., copper and mercury), it was assumed that the site-specific bioaccumulation models for fish were suitable.

Terrestrial Plants

Site-specific data for estimation of bioaccumulation by terrestrial plants from soil were generally limited. To determine whether existing bioaccumulation models for terrestrial plants were representative of bioaccumulation in the Coeur d'Alene River basin, Coeur d'Alene data were plotted over the data from the existing models (Figures 3.1.2.6.1.3-5 through 3.1.2.6.1.3-8). Because bioaccumulation from the Coeur d'Alene River basin usually fell within the 95 percent prediction intervals for the plant bioaccumulation models presented in Bechtel Jacobs (1998), these models were assumed to be representative of plant bioaccumulation in the Coeur d'Alene River basin. Parameters for the plant bioaccumulation models are summarized in Table 3.1.2.6.1.3-6.

Terrestrial Invertebrates

Site-specific data for estimation of bioaccumulation by terrestrial invertebrates were not available. As a consequence, models were developed based on published literature. Data acquisition and model development efforts focused on terrestrial arthropods as being most representative of terrestrial invertebrate prey of birds and mammals. In the absence of arthropod data, earthworm data were used as a conservative representation. A summary of data used to derive soil-to-arthropod bioaccumulation models is presented in Appendix C, Table C.3.1.2.6.1.3-1. Log-linear regression models were fitted to these data. Scatterplots of the relationships between COPEC concentrations in soil and terrestrial arthropods are presented in Figure 3.1.2.6.1.3-9. Significant loglinear relationships were obtained for cadmium, copper, and lead (Table 3.1.2.6.1.3-7). Because a significant fit was not obtained for zinc, soil-arthropod bioaccumulation factors (BAFs) were calculated; the median, minimum, 90th percentile, and maximum BAF were 0.36, 0.01, 2.9, and 9.8. Arthropod data were not available for arsenic or mercury. Bioaccumulation models for earthworms were assumed to be suitable (Table 3.1.2.6.1.3-7).

Small Mammals

Site-specific data for estimation of bioaccumulation by small mammals from soil were generally limited. To determine if existing bioaccumulation models for small mammals were representative of bioaccumulation in the Coeur d'Alene River basin, Coeur d'Alene data were plotted over the data from the existing models (Figures 3.1.2.6.1.3-10 and 3.1.2.6.1.3-11). Because bioaccumulation from the Coeur d'Alene River basin generally fell within the 95 percent prediction intervals for the herbivorous small mammal models presented in Sample et al. (1998; these models were selected over other models for cadmium and lead because they possessed the highest r-square values), these models were assumed to be representative of bioaccumulation by small mammals in the Coeur d'Alene River basin. Parameters for the small mammal bioaccumulation models to be used for the Coeur d'Alene River basin are summarized in Table 3.1.2.6.1.3-8. Because significant regression models were not available for mercury (Sample et al. 1998), BAFs were used; the median, minimum, 90th percentile, and maximum BAFs (based on general small mammals) were 0.054, 0.018, 0.19, and 1.05.

3.1.2.6.1.4 Assumptions

does this look at [illegible] value of a big database

To establish parameters for the exposure model, various assumptions were necessary. These assumptions are listed below:

Exposure-point concentrations for soil-sediment, and surface water incorporated into the exposure model consisted of the higher of either the 90th percentile or the upper 95 percent confidence limit of the arithmetic mean (95 percent UCL) concentrations. These values were selected to provide a conservative representation of exposures likely to be experienced by birds and mammals within the Coeur d'Alene River basin. Because wildlife are mobile and their exposure is best represented by the average concentration within areas they inhabit, 95 percent UCL is the measure traditionally used for estimation of exposure for wildlife (Suter et al. 2000). However, estimation of the 95 percent UCL is influenced by the Central Limit Theorem – as the sample size increases, the confidence limit about the mean decreases in size. A consequence of this relationship is that confidence limits based on large samples are very narrow and represent only a small portion of the full distribution. This was observed to occur with data from the Coeur d'Alene River basin; due to very large sample sizes (in some cases >1000 samples) confidence limits were extremely narrow, in some cases being only marginally greater than mean concentrations. Because the use of these 95 percent UCLs would have resulted in non-protective exposure estimates, the larger of either the 90th percentile or the 95 percent UCL was used. The resulting exposure estimates are ensured to account for ≥90 percent of all possible exposure levels.

3.1.2.6.1.5 External Exposure Estimates

Based on the models, parameters, and assumptions outlined above, external exposure estimates were generated for each receptor identified to occur within specific habitats in each CSM unit and segment or watershed. Summaries of total (i.e., sum over all pathways) and partial (pathway-specific exposure) external exposure estimates are presented and compared to toxicity values in Section 4.1.1.1.

3.1.2.6.2 Internal Exposures

Internal exposures consist of measured or estimated concentrations of COPECs in tissues of receptor species. Comparison of these tissue concentrations to concentrations associated with effects provide another measure of the potential nature and magnitude of effects birds and mammals may experience in the Coeur d'Alene River basin.

3.1.2.6.2.1 Measured Internal Exposures

Blood Lead

Concentrations of lead in blood of birds from the Coeur d'Alene River basin have been monitored by the USFWS for multiple years. These data have been reported in multiple publications (e.g., Audet et al. 1999, Blus et al. 1993, Blus et al. 1995, Henny et al. 1991, Henny et al. 1994, etc.). Blood lead data were extracted from the original data files that were obtained from the USFWS. Summary statistics for concentrations of lead observed in birds from the Coeur d'Alene River basin and regional reference areas are presented in Table 3.1.2.6.2.1-1.

COPEC Concentrations in Avian and Mammalian Organs

Concentrations of COPECs in livers and kidneys of birds and mammals from the Coeur d'Alene River basin have been monitored by the USFWS for multiple years. These data have been reported in multiple publications (e.g., Audet et al. 1999, Blus et al. 1987, Blus and Henny 1990, Blus et al. 1993, Blus et al. 1995, Henny et al. 1991, Henny et al. 1994, etc.). Organ concentration data for birds and mammals were compiled from both published and unpublished sources. Summary statistics for COPEC concentrations in organs from mammals from the Coeur d'Alene River basin and regional reference areas are presented in Table 3.1.2.6.2.1-2. Summary statistics for COPEC concentrations in organs from birds from the Coeur d'Alene River basin and regional reference areas are presented in Table 3.1.2.6.2.1-3.

3.1.2.6.2.2 Modeled Internal Exposures

Models for estimation of COPEC concentrations in blood and organs of birds and mammals were developed based on either site-specific data or on literature-derived data. These models are summarized below.

Site-specific Waterfowl Model

A sediment-to-waterfowl blood and liver model for lead was developed based on an adaptation of the exposure/effects model presented in Beyer and Audet (1999). The model is of the form:

$$C_{Pb} = e^{\left[\text{slope} \times \ln\left[C_s \times \left[\frac{b-y+ay}{ay-c+b}\right]\right] + \text{intercept}\right]}$$

Where:

C_{Pb} = Estimated concentration of lead in blood or liver (mg/kg wet weight). Separate estimates were generated for tundra swan, Canada goose, mallard, and wood duck.

a = proportion digestibility of diet (0.5 dry mass for tundra swan, mallard, and Canada goose [Beyer et al. 1998]; 0.6 dry mass for wood duck [Beyer et al. 1997])

b = proportion of acid-insoluble ash in diet (0.02 dry mass; Beyer et al. 1998)

c = proportion of acid-insoluble ash in sediment (0.9 dry mass; Beyer et al. 1994)

y = proportion of acid-insoluble ash in scat (to be conservative, used 90th percentile values; 0.35 dry mass for tundra swan, 0.28 dry mass for Canada goose, and 0.22 dry mass for mallard [Beyer et al. 1998]; used maximum value for wood duck, 0.173 dry mass [Beyer et al. 1997])

C_s = concentration of Pb in sediment (mg/kg dry weight)

slope = slope from diet-blood or diet-liver regression model (discussed below)

intercept = intercept from diet-blood or diet-liver regression model (discussed below)

Previous research has indicated exposure of waterfowl to lead through the food pathway is trivial compared to exposure from incidental sediment ingestion (Beyer and Audet 1999). Therefore, oral or dietary exposure is equivalent to sediment exposure. Diet-to-blood and diet-to-liver bioaccumulation models were developed using data from studies in which waterfowl were fed diets containing sediment from the Coeur d'Alene River basin (Hoffman et al. 1999, Heinz et al. 1999, and Day et al. 1998). Data used to describe diet-to-blood and diet-to-liver bioaccumulation are presented in Appendix C, Table C.3.1.2.6.2.2-1. Scatter-plots displaying the relationships between dietary lead and lead in blood or liver are presented in Figures 3.1.2.6.2.2-1 and 3.1.2.6.2.2-2, respectively. The diet-blood regression model was:

$$\ln(\text{blood}_{Pb})=0.662\text{x}(\ln[\text{diet}_{Pb}])-3.284 \text{ } (n=38, p<0.0001, r^2=0.88).$$

The diet-liver regression model was:

$$\ln(\text{liver}_{Pb})=0.810\text{x}(\ln[\text{diet}_{Pb}])-2.941 \text{ } (n=23, p<0.0001, r^2=0.86).$$

The model outlined above was applied to wetland soil-sediment lead concentrations measured in the Coeur d'Alene River basin. Summary statistics for estimated blood and liver lead concentrations in waterfowl in the Coeur d'Alene River basin are presented in Appendix C, Table C.3.1.2.6.2.2-2.

American Dipper Models

Although data concerning accumulation of COPECs from diet by American dippers were not collected from within the Coeur d'Alene River basin, such data have been collected by the USFWS from the Arkansas River basin in Colorado *[[Reference??]]*. Concentrations of cadmium, copper, mercury, lead, and zinc were measured in aquatic invertebrates (prey of American dippers) and blood and liver of American dippers from multiple locations within the Arkansas River basin of Colorado. Loglinear regression analyses were performed on these data (Table 3.1.2.6.2.2-1). Although significant model fits were obtained for cadmium and lead for blood, and for cadmium, lead and zinc for liver (Table 3.1.2.6.2.2-1), only for lead in blood and cadmium and lead in liver were r-square values sufficiently high (>0.2) to warrant application of the models for predictive purposes.

Diet-American dipper tissue models were coupled with site-specific sediment-to-aquatic invertebrate models (see Table 3.1.2.6.1.3-3) to create a sediment-to-American dipper tissue model:

$$\text{Tissue (mg / kg wet wt.)} = e^{[M_1(M_2[\ln C_s]+b_2)+b_1]}$$

Where:

M_1 = slope from the diet-to-tissue regression model

M_2 = slope from the sediment-to-aquatic invertebrate regression model

C_s = COPEC concentration in sediment (mg/kg dry)

b_1 = intercept from the diet-to-tissue regression model

b_2 = intercept from the sediment-to-aquatic invertebrate regression model

These models were applied to sediment data from the Coeur d'Alene River basin to generate estimated concentrations of cadmium and lead in tissues of American dippers (Table 3.1.2.6.2.2-2).

~~What~~ Was NRDA small mammal work included here?

Small Mammal Models

Previous research has shown that concentrations of chemicals in small mammal tissues may be estimated based on soil concentrations (Sample et al. 1998, Shore 1995). As an alternative approach for exposure estimation, soil-to-liver and soil-to-kidney bioaccumulation models were developed for small mammals based on literature-derived data. Using an approach comparable to that employed in Sample et al. (1998), co-located soil and small mammal organ concentration data were extracted from published studies. Data used for model development are summarized in Appendix C, Tables C.3.1.2.6.2.2-3 and C.3.1.2.6.2.2-4. Log-linear regression models were developed for all small mammals combined and for specific trophic guilds (e.g., insectivores, herbivores, and omnivores). Soil-kidney and soil-liver regression models are summarized in Tables 3.1.2.6.2.2-3 and 3.1.2.6.2.2-4, respectively. Models for r-square values of 0.2 or greater were obtained were applied to soil data from the Coeur d'Alene River basin to generate estimated concentrations of cadmium, lead, and zinc in tissues of insectivorous, herbivorous, and omnivorous small mammals (Appendix C, Table C.3.1.2.6.2.2-5). Estimates for insectivorous small mammals are assumed to be representative of water, masked, and vagrant shrews; estimates for herbivorous small mammals are assumed to be representative of meadow voles; and estimates for omnivorous small mammals are assumed to be representative of deer mice.

3.2 ECOLOGICAL EFFECTS CHARACTERIZATION

3.2.1 Chemical Stressor-Response Analyses

Stressor-response (i.e., effects) data that may be used to evaluate ecological risks resulting from chemical exposures fall into three general categories: literature-derived or site-specific single-chemical toxicity data, site-specific ambient media toxicity tests, and site-specific field surveys (Suter et al. 2000). All three categories of data were available for the assessment of ecological risks in the Coeur d'Alene River basin and are summarized below.

3.2.1.1 Literature-Derived and Site-Specific Single Chemical Toxicity Values

Single-chemical toxicity data consist of results of toxicity tests with single chemicals (or materials) as reported in published literature or performed on a site-specific basis. These data may also be represented as summaries of literature toxicity data (e.g., water quality criteria). These toxicity data may be expressed in terms of exposure media (e.g., mg/kg soil or sediment; mg/L water), as dietary concentrations or doses (i.e., mg/kg or mg/kg/d), or as concentrations in target organs (e.g., blood, liver, kidney) that are associated with effects. Single chemical toxicity data developed for use in this EcoRA are summarized below.

3.2.1.1.1 Fish and Aquatic Invertebrates

The site-specific testing results and summaries of toxicity of metals to aquatic life from EPA ambient water quality criteria documents, the ACQUIRE data base, and testing done in, or with respect to, the Coeur d'Alene River basin have been used to develop cumulative-response profiles for risk analysis, and as part of a weight-of-evidence approach in risk analysis. Some of the testing done within, or with respect to, the Coeur d'Alene River basin; that done by the University of Wyoming and Stratus for EPA (bull trout tests), and for EPA by Dames and Moore (1989), and various authors for the Coeur d'Alene River basin NRDA trustees were summarized for EPA by Stratus (1999a, draft) for cadmium, lead, and zinc, but have not all been systematically incorporated in the draft cumulative response profiles yet. Some of the site-specific tests were done with mixtures of metals in dilutions of water from the South Fork of the Coeur d'Alene River, and do no lend themselves to use in the cumulative response profiles. Those test results will be used in the EcoRA to assess site-specific conditions that may modify the underlying toxicity of the individual metals, and to help address the issue of metals mixtures when estimating risks. Other testing done within the basin; (for example, testing done by EVS Consultants for the State of Idaho) is not yet included in the cumulative response profiles. We

when is this info going to be incorporat supplemented the Stratus (1999a) summary with additional data from the EPA ambient water quality criteria documents for the respective metals, and added data from the EPA criteria documents and the ACQUIRE data base for copper, mercury, and silver.

The draft cumulative response profiles (Figures 3.2.1.1-1 through 3.2.1.1-8 show the ranked order of sensitivity to selected taxa of aquatic animals versus the ranges and means of their responses to cadmium, copper, lead, mercury, silver, and zinc. The taxa (e.g., class, order, family, species) were selected based on their known presence in the Coeur d'Alene River basin (in the case of the higher level taxa, the species tested may be different than the species present in the Coeur d'Alene River basin). The toxic responses shown for the draft cumulative response profiles of acute toxicity are the respective LC-50s for the acute effects. The various chronic endpoints cited in **Appendix H**, or the EPA final chronic values, were used to construct the draft cumulative response profiles of chronic effects. In general, the ACQUIRE data base listed the chronic endpoints (e.g., growth, survival) measured in the tests cited, while the EPA ambient water quality criteria documents and Stratus (1999a) did not.

is this a cheap shot at stratus?

The ACQUIRE data base contains unverified information and depends on the sources of information entered for determining the categories (acute or chronic) assigned to the test results. ACQUIRE results (Stratus 1999a) included several suspect values for chronic endpoints for cadmium (ranging from about 100 µg/L to 140 µg/L) that were much higher than the range of LC 50s reported in the acute toxicity test results listed in the EPA ambient water quality criteria documents for cadmium (USEPA 1980, 1984). The bases for those tests were determined from Table 6 of the EPA 1980 and 1984 criteria documents for cadmium. The results were, with one exception, found to be inappropriately classified as chronic tests, and all were deleted from the data used to construct the chronic cumulative response profile for cadmium. The one exception was an endpoint of reduced growth and survival of rainbow trout measured by Woodworth and Pascoe (1982) at 100 µg/L. That result was also deleted, but the original paper will be obtained to verify that decision. There are several other tests currently included in the draft cumulative chronic response profiles that are suspect based on the duration of the tests (e.g., 8.3-day tests from the ACQUIRE data base included as chronic tests with cadmium for chinook salmon and rainbow trout) rather than inconsistent test results. Those tests will also be verified by consulting the original references.

The chronic test with bull trout exposed to cadmium for 55 days (Stratus 1999b) had not been completed at the time Stratus (1999a) completed their draft summary report. The single chronic endpoint of 0.786 µg/L for reduced growth and survival is included on the draft cumulative chronic response profile for cadmium (Figure 3.2.1.1-2). The acute testing results for bull trout (Stratus 1999c) were included in the draft acute cumulative response profiles for cadmium (Figure 3.2.1.1-1) and zinc (Figure 3.2.1.1-7).

The toxicity endpoints shown on the draft cumulative response profiles were normalized to a hardness (H) of 50 mg/L as $CaCO_3$ for metals whose toxicity varies as a function of water hardness.. This was done by multiplying the endpoint concentration at the test hardness by a ratio determined as the ambient water quality criterion at the test hardness divided by the ambient water quality criterion at hardness = 50 mg/L. The respective ambient water quality criteria at H = 50 mg/L are also shown on Figures 1 through 12 for comparison with the toxicity test endpoints, and criteria values for hardness = 30, 50, and 100 mg/L are shown in Table 3.2.1.1-1 to illustrate the effects of hardness over the approximate range reported in the Coeur d'Alene River basin on the ambient water quality criteria.

Because of the approach used to derive the ambient water quality criteria, the criteria values are expected to usually fall below the cumulative response distributions when the distributions contain only a limited number of taxa. The national criteria are set to protect approximately 95 percent of aquatic species. Note however, that we have plotted the LC 50s as the acute response. In establishing the national criteria, EPA divides the final acute values (which are based on LC 50s) by two to approximate a low- or no- acute effect level.

The national acute criteria (Criteria Maximum Concentration or CMC; USEPA1998, 1999) are considered to be an estimate of the highest concentrations of materials in surface water to which an aquatic community can be exposed briefly without causing an adverse effect. The national chronic criteria (Criteria Continuous Concentration or CCC; USEPA 1999) are estimates of the highest concentrations of materials in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect. The chronic criteria are thus the logical basis for PRGs in the Coeur d'Alene River basin, given the more or less continuous nature of most of the releases of metals. The chronic cumulative response profiles (even numbered Figures 3.1.1-2 through 3.2.1.1-8) can be used to judge what components of aquatic communities might be lost if the chronic criteria cannot be achieved by selected remedial actions. The acute cumulative response profiles (odd numbered Figures 3.2.1.1-1 through 3.2.1.1-7) can be used to judge effects of short term exceedances of PRGs.

Currently there are no U.S. EPA sediment criteria for total metals in sediment. In general, it is difficult to predict sediment concentrations at which toxicity occurs because the type and form of the sediment and the water chemistry of the overlying water influence metal speciation and bioavailability. For example, the bioavailability of metals in sediment is strongly influenced by the amount of organic carbon, Fe-oxyhydroxides, and acid volatile sulfides (AV S) in sediments (see Di Toro et al., 1990; Di Toro et al., 1992; Tessier et al., 1993). However, sediment guidelines have been derived for metals based on the relationship between the bulk metal concentration in the sediment, the metal concentration in the pore water, and measured biological effects (e.g., Ingersoll et al., 1996; Long and Morgan, 1989; Persaud et al., 1993). These sediment guidelines provide an initial benchmark for predicting the potential for adverse effects due to elevated metal concentrations in sediment. Those possible sediment benchmarks from the literature including freshwater sediment benchmarks that were revised by NOAA in September 1999 (Buchman, 1999), and the Interim Sediment Quality Guidelines (ISQGs) for Canada (CCME, 1999) are summarized in Table 3.2.1.1-2. The Threshold Effects Levels (TELs) from NOAA and the ISQGs from Canada are identical. Regional background values of metals in soil exceed the potential PRGs, so upper background values for soil (Table 2.3.2-2) were selected as the PRGs for sediments in the CDA Basin.This was done with the assumption that sediments are derived from soils throughout the basin, and because it is not considered appropriate to select a PRG below the background value. Where site-specific bioassays or other information is available for sediments within particular Conceptual Site Model (CSM) units, the site-specific information will be used in a weight-of evidence evaluation of risks from exposure to contaminated sediment.

3.2.1.1.2 Benthic Invertebrates [Section deleted]

3.2.1.1.3 Aquatic Plants [Section deleted]

3.2.1.1.4 Amphibians

Toxicity values for amphibians were derived from a single document that compiled toxicity data from numerous sources: Amphibian Toxicity Data for Water Quality Criteria Chemicals (Schuytema and Nebeker 1996). Specific toxicity values were not selected for each COPEC. Rather, cumulative distributions of toxicity values reported in each source (e.g., NOECs and LOECs) were developed. In this way, the full distribution of available toxicity data may be compared to the distribution COPEC concentrations in water to determine the magnitude of exceedence. This approach provides more information concerning the nature and magnitude of risks that may be present. Because Schuytema and Nebeker (1996) present data by embryo, larval, and adult life stages, separate distributions were developed for each. Cumulative distributions of amphibian toxicity data for arsenic, cadmium, copper, inorganic mercury, organic mercury, lead, silver, and zinc are presented in Figures 3.2.1.1.4-1 through 3.2.1.1.4-8. Data used to develop these figures are presented in Appendix C, Table C.3.2.1.1.4-1. All data in Schuytema and Nebeker (1996) are expressed as concentrations in water (µg/L).

3.2.1.1.5 Terrestrial Plants

Toxicity values for terrestrial plants were derived from two sources: Oak Ridge National Laboratory (ORNL) plant benchmarks (Efroymson et al. 1997a), and site-specific toxicity tests performed on Coeur d'Alene River basin soils (LeJeune et al. 1999). The ORNL plant benchmarks represent a compilation of toxicity data from numerous sources and have undergone extensive review and evaluation.

Specific toxicity values were not selected for each COPEC. Rather, cumulative distributions of toxicity values reported in each source (e.g., NOECs and LOECs; and 10, 20, and 30 percent effects concentrations [EC_{10}, EC_{20}, and EC_{30}]) were developed. Cumulative distributions of phytotoxicity data for arsenic, cadmium, copper, lead, and zinc are presented in Figures 3.2.1.1.5-1 through 3.2.1.1.5-5. Data used to develop these figures are presented in Appendix C, Tables C.3.2.1.1.5-1 through C.3.2.1.1.5-3. It should be noted that the EC_{10}, EC_{20}, and EC_{30} values from LeJeune et al. (1999) were derived only from the tests on alfalfa, wheat, and lettuce and were only available for cadmium, lead, and zinc. Kapustka (1999) reports that phytotoxicity was most closely correlated with these COPECs. Although site-specific toxicity values from the hybrid poplar tests were not reported by either LeJeune et al. (1999) or Kapustka (1999) due to the greater variability of the results, Kapustka (1999) states that poplar growth was related to lead and zinc concentrations.

3.2.1.1.6 Soil Invertebrates

Toxicity values for soil invertebrates, represented by earthworms, were derived from a single source: ORNL soil invertebrate benchmarks (Efroymson et al. 1997b). These benchmarks represent a compilation of toxicity data from numerous sources and have undergone extensive review and evaluation.

As with plants and invertebrates, specific toxicity values were not selected for each COPEC. Instead, cumulative distributions of toxicity values were developed. Cumulative distributions of earthworm toxicity data for cadmium, copper, lead, and zinc are presented in Figures 3.2.1.1.6-1 through 3.2.1.1.6-4. As no NOEC and only one LOEC were available for arsenic, a cumulative distribution (and figure) were not developed for this COPEC. Data used to develop these figures are presented in Appendix C, Tables C.3.2.1.1.6-1 and C.3.2.1.1.6-2.

3.2.1.1.7 Microbial Processes

Toxicity values for soil microbial processes were derived from a single source: ORNL soil microbial processes benchmarks (Efroymson et al. 1997b). These benchmarks represent a compilation of toxicity data from numerous sources and have undergone extensive review and evaluation.

As with plants, specific toxicity values were not selected for each COPEC. Rather, cumulative distributions of toxicity values were developed. Cumulative distributions of microbial process toxicity data for arsenic, cadmium, copper, lead, and zinc are presented in Figures 3.2.1.1.7-1 through 3.2.1.1.7-5. Data used to develop these figures are presented in Appendix C, Tables C.3.2.1.1.7-1 and C.3.2.1.1.7-2.

3.2.1.1.8 Birds and Mammals

3.2.1.1.8.1 External Exposures

External exposures are evaluated using toxicity data from oral exposure studies.

Oral toxicity values for birds and mammals were derived by extracting no and lowest observed adverse effects levels (NOAELs and LOAELs) from published literature, building on the wildlife benchmarks developed at Oak Ridge National Laboratory (e.g., Sample et al. 1996). Because NOAELs and LOAELs are statistically derived measures of effects, are a function of the quality of the design of the toxicity study, and do not provide any information concerning the magnitude of effects associated with a given exposure, dose-response functions were also developed for all studies for which data were adequate. A modeling approach derived from the Benchmark dose methodology (Crump 1984) being evaluated by the USEPA for human health risk assessment (e.g., Kimmel et al. 1995) was used. The model is of the form:

$$y = a_0 + \frac{(a_1 - a_0)}{1 + e^{b_0 + b_1 x}}$$

Where:

y = response

x = dose or transformed dose (e.g., log)

a_0 = minimum expected value for response (y)

a_1 = maximum expected value for response (y)

b_0, b_1 = slope and inflection parameters.

The model is a 2-, 3-, or 4-parameter logistic-type model that may be applied to either binary (e.g. survival) or continuous (e.g., growth, reproduction, etc.) data. Number of parameters is determined by the attributes of the dose-response data. Initial estimates of a_0 and a_1 are based on the minimum and maximum response data. Initial estimates of b_0 and b_1 are obtained by regressing:

$$z = \ln[\frac{(\hat{a}_1 - y)}{(y - \hat{a}_0)}]$$

on x. The slope and intercept are the initial estimates of b_1 and b_0, respectively. Using the above initial estimates, the NLIN procedure (non-linear regression; SAS 1989) is used to obtain the weighted least-squares estimates of the parameters and their associated standard errors. Weights are based on response standard errors. The resulting model is then used to define the dose level (and 95 percent confidence limits) that corresponds with selected standardized effect levels (e.g., ED_5 to ED_{50}).

Avian and mammalian toxicity data developed for arsenic, cadmium, copper, mercury, lead and zinc are summarized in Table 3.2.1.1.8.1-1. Information concerning assumptions made as part of the extraction of data from each study is presented in Appendix C.

Multiple toxicity studies were available for both birds and mammals for each analyte. Toxicity studies were selected to serve as the primary toxicity reference value (TRV) if: exposure was chronic or during reproduction, the dosing regime was sufficient to identify both a NOAEL and a LOAEL and allow for dose-response curve-fitting, and the study considered ecologically relevant effects (i.e., reproduction, mortality, growth). If multiple studies for a given COPEC met these criteria, the study generating the lowest reliable TRV was selected to be the primary TRV. Primary TRVs were used for all initial evaluations of the exposure estimates and are highlighted in Table 3.2.1.1.8.1-1. Allometric scaling factors for birds and mammals of 1.2 and 0.94, respectively (Sample and Arenal 1999) were used to estimate species-specific TRVs from literature-derived TRVs.

3.2.1.1.8.2 Internal Exposures

Internal exposures consist of measured or estimated concentrations of COPECs in target organs (e.g., blood, liver, or kidney) of receptor birds and mammals. Concentrations of COPECs in these target organs that have been associated with effects in field or laboratory animals are used to evaluate internal exposure data. Target organ effects concentration data were derived from both site-specific observations and published studies.

Target organ effect concentrations derived from published sources are summarized in Table 3.2.1.1.8.2-1. Due to extensive research that has been conducted concerning effects of environmental lead (primarily as lead shot) on birds, more detailed target organ effects data are available (Table 3.2.1.1.8.2-2).

A limited amount of site-specific target organ effects data are also available. Audet et al. (1998) report concentrations of lead in livers of waterfowl and other birds found dead in the Coeur d'Alene River basin between 1992 and 1996. Based on pathology analyses, all dead birds were categorized as being either lead poisoned (both with and without lead artifacts such as shot or fishing sinkers) or having died of causes other than lead-poisoning (e.g., trauma, electrocution, disease, etc.). Mean concentration of liver lead in birds diagnosed as lead poisoned (both with and without lead artifacts) was greater than 16 mg/kg wet weight, whereas mean liver lead concentration among birds that died from other causes was <2 mg/kg wet weight (Table 3.2.1.1.8.2-3). Additional data based on a nationwide retrospective study of lead concentrations in livers of waterfowl diagnosed as lead-poisoned are also presented for comparison (Table 3.2.1.1.8.2-3).

Blood lead concentrations in waterfowl also have been measured in the Coeur d'Alene River basin (Table 3.2.1.1.8.2-4). Beyer and Audet (1999) report blood lead concentrations from moribund tundra swans. Additional data concerning blood lead in apparently healthy swans, Canada geese, and mallards from within the basin and at adjacent reference areas are presented for comparison (Table 3.2.1.1.8.2-4).

3.2.1.2 Site-Specific Ambient Media Toxicity Tests

Site-specific toxicity tests have been done in the CdA basin (typically in the SFCDR). These studies provide important information on the toxic effects that have been observed in site-relevant organisms in site water. These organisms have been exposed under water quality conditions that are by definition appropriate for the site water body (at least under the conditions sampled). Several site-specific acute lethality tests have been did with salmonids (EVS 1996a, 1996b 1997b; Dames and Moore 1989; Hornig et al. 1988; Woodward and Farag 1995; Woodward et al. 1999) and invertebrates (EVS 1996b 1997b 1998; Dames and Moore 1989). Site-specific data of benthic communities have also been collected (Stokes and Ralston 1972; Savage and Rabe 1973; Dames and Moore 1989). These tests are summarized in the subsequent sections and evaluated with respect to deriving TRVs.

3.2.1.2.1 Acute Lethality Testing with Salmonids

EVS (1 996a, I 996b, 1 997b) did toxicity tests using water collected from various locations in the SFCDR. EVS (1 996a) observed 44 percent mortality in hatchery-reared rainbow trout exposed to 10 percent Canyon Creek water (water hardness not given) and 47 percent mortality in hatchery-reared rainbow trout exposed to 100 percent SFCDR water collected near Wallace (water hardness not given).

EVS (1996b 1997b) also observed mortality in hatchery reared cutthroat and rainbow trout exposed to Cd, Pb, or Zn individually in water collected from the Little North Fork (LN F) of the SFCDR (hardness 18-21 *mg/L).* All three metals were acutely lethal to both trout species at relatively low total metal concentrations (Table 3.2.1.2-1). When normalized to a hardness of 50 mg/L, 60-86 percent mortality was observed at Cd concentrations between 1.25 and 2.25 μg/L, 20-40 percent mortality was observed at Pb concentrations between 65.5 and 273 μg/L, and 30-35 percent mortality was observed at a Zn concentration of 132 μg/L. With respect to Cd, acute lethality (60-86 percent mortality) was observed in salmonids exposed to Cd (added to site water) at Cd concentrations predicted to be protective of aquatic life (EPA, 1996).

Dames and Moore (1989) did a series of acute toxicity tests *in situ* with site water collected from various locations on the SFCDR and the NFCDR with rainbow trout. Fish were exposed in cages to 100 percent site water. Water hardness values ranged from 18 to 168 mg/L over three testing periods In all tests did with site water collected from the SFCDR, Dames and Moore (1989) observed 100 percent mortality after the 96-hour exposure period (Table 3.2.1.2-2). Fish exposed for 96 hours in the NFCDR (a field and cage control) had 30-55 percent mortality after 96 hours of exposure. Fish exposed in the NFC DR did not show external signs of metal induced stress, which was observed in fish exposed in the SFCDR (e.g., loss of equilibrium, gill discoloration, excess gill mucous), but did show excessive scale loss indicative of physical trauma within the cage, possibly resulting from high water velocities in the NFCDR (Dames and Moore 1989). Metal concentrations in the SFCDR associated with 100 percent mortality (normalized to a hardness of 50 mg/L) were between 2.26 and 7.88 μg Cd/L, 5.4 and 13.1 μg Pb/L, and 857 and 1470 μg Zn/L (Table 3.2.1.2-3). Since the Cd and Zn concentrations but not the Pb concentrations are higher than the applicable dissolved AWQC, it is likely that the observed mortality in these *in situ* tests was due to the elevated Cd and Zn concentrations.

Lethality of rainbow trout *in Situ* in live box exposures was also determined by the U.S. EPA in September 1986 (Hornig et al. 1988). Rainbow trout were placed in cages at eight locations along the SFCDR, at one location in the NFCDR, and in the main stem CDR. Mortality after 96 hours of exposure in the SFCDR ranged from 40-100 percent downstream of the confluence of Canyon Creek to 0 percent in SFCDR headwaters (upstream of the confluence of Canyon Creek). Water hardness was not measured. Cd and Zn concentrations measured in the SFCDR downstream of Canyon Creek ranged from 15 to 29 μg/L and from 1480 to 2800 μg/L, respectively. *In situ* tests with similar results were did by the U.S. EPA in June 1973, July 1979, September 1979, and September 1982 at multiple stations along the SFCDR (Hornig et al. 1988).

Woodward and Farag *(1995)* observed 100 percent mortality within 72 hours in westslope cutthroat trout held in cages exposed to 70 percent NFCDR and 30 percent SFCDR water. Subsequent *in situ* caging experiments with westslope cutthroat trout and rainbow trout resulted in 100 percent mortality in fish held in the SFCDR, 97 percent mortality in fish held at the confluence of the NFCDR and the SFCDR, and no mortality in fish held for 96 hours in the NFCDR (Woodward and Farag 1995). The hardness of the water was not measured. Metal concentrations in the SFCDR at approximately the same time as the caging study ranged from 8.5 to 9.3 μg Cdl, 25.5 to 31.8 μg Pb/L, and 1.75 to 1.93 mg Zn/L (Woodward and Farag 1995).

Woodward et al. (1999) did *in situ* caging experiments with westslope cutthroat trout at sites in the SFCDR and the St. Regis River selected as having similar habitats. Mortality was 30 percent al site SF24 and 100 percent at sites SF0, SF8, and SF16 after 96 hours of exposure (Table 3.2.1.2-4). Mortality was 0 percent at SF32 and at all the (control) paired St. Regis River sites. Mean metal concentrations at the SF0, SF8, and SF16 sites ranged from 7.1 to 12 μg Cd/L, 12 to 43 μg Pb/L, and 805 to 2440 μg Zn/L (Woodward et al. 1999). Hardness varied from 21 to 188 mg/L along the SFCDR from sites SF0 to SF32. When metal concentrations at SF0, SF8 and SF16 are normalized to a hardness of 50 mg/L, they range from 1.94 to 5.01 μg Cd/L, 2.84 to

17.5 µg Pb/L, and 357 to 794 mg Zn/L (Table 3.2.1.2-4). The normalized Cd concentrations where 100 percent mortality was observed are similar to the existing dissolved AWQC for Cd.

3.2.1.2.3 Terrestrial Plants

A single series of site-specific phytotoxicity tests were conducted by Hagler-Bailly Consulting (1995) as part of the damage assessment data development. These bioassays are described below.

Controlled laboratory experiments were used to examine the link between vegetative growth and hazardous substances in soils collected from the Coeur d'Alene River basin. Standard test plant species, alfalfa, wheat and lettuce were sown into soils collected from four assessment sites and four reference sites from the Coeur d'Alene River basin. In addition, rooted hybrid poplars were grown in soils from the assessment and reference sites to examine the potential effects on native riparian trees. For the standard test plants, measurements were made on root length and mass and shoot length and mass of each species. New shoot height and mass, maximum new root length and mass, and new stem mass were measured on the poplars. To ensure all other environmental factors were standardized for all treatments, plants were grown in growth chambers and the water-holding capacity was maintained for each soil throughout the duration of the experiment. All reference and all assessment sites were combined for data analysis. Nested analysis of variance was used to test for differences between treatments and correlation analysis was used to evaluate the relationships between vegetative growth and soils.

Soils analysis indicated that the soils from the assessment areas had significantly higher amounts of arsenic, lead, copper and zinc. Results indicated that plant growth was significantly reduced for all species grown in the assessment soils relative to the reference soils. Correlation analysis indicated that both root length and mass, and shoot length and mass were significantly negatively correlated with the concentration of hazardous material in the soils, and positively related to pH. As the metal concentration increased, pH and plant growth decreased. Branch and root length, leaf mass, and the number of roots and leaves for the hybrid poplars were also significantly negatively correlated with increased metal concentration in the soils.

Results from the carefully controlled laboratory tests clearly demonstrated that the assessment soils from the Coeur d'Alene River basin have phytotoxic effects on plants relative to uncontaminated reference soils. Correlation analysis provided strong evidence that the poor vegetative growth was a direct result of increased concentrations of hazardous materials in the soils.

3.2.1.2.4 Amphibians, Birds and Mammals

Two, four, and two site specific toxicity studies were conducted with amphibian, avian, and mammalian receptors, respectively. These studies are summarized below.

3.2.1.2.4.1 Amphibians

Lefcort et al. (1998)

Laboratory experiments were conducted to determine the effects of contaminated sediments on survival, growth, metamorphosis and behavior of tadpoles of the Columbia spotted frog (*Rana luteiventris*). The experiments were designed to examine the effects of single heavy metal elements and combinations of metals found in contaminated sediments from the Bunker Hill Superfund site. Forty-eight mini-ecosystems were constructed and assigned one of twelve metal treatments. Metal concentrations of lead (50, 5 and 0.01 ppm), zinc (50, 15, 0.05 ppm) and cadmium (20, 5 and 0.1 ppm) were based on measurements of field concentrations from the assessment area. Sediments from the contaminated area (1,000 and 100 ml) were used for two treatments, however, the metal concentration was not measured. The final treatment was an uncontaminated control. Fifty two-week-old tadpoles were placed in each tank and measurements were recorded weekly. Metal concentrations in the tadpoles and water were determined after three weeks. A gravitational flow-through system was used to test the behavioral response of tadpoles exposed to metals to chemical cues from a predator (rainbow trout). Tadpoles were placed in tanks with vegetation on one side and open water on the other. The activity and movement of the tadpoles was monitored both before and after exposure to water from the trout tank. Both students t-test and analysis of variance using the Student-Newman-Keuls multiple comparison of means tests were used in data analysis.

Tadpole survival to metamorphosis was dependent on the metal treatment, with those in the control and low concentrations having higher levels of survivorship than all other treatments. The high and medium concentrations of zinc and cadmium resulted in 100 percent mortality prior to metamorphosis. Mean age at which metamorphosis occurred was also dependent on treatment, with those tadpoles exposed to the Superfund soils having significantly delayed metamorphosis relative to other treatments. Tadpoles with delayed metamorphosis had greater mean weight at the time of metamorphosis, and the control group had greater body mass at metamorphosis than those exposed to low levels of lead and zinc. Metals also had a significant effect on tadpole behavioral activity. Tadpoles that were not exposed to metals demonstrated greater movement overall, both in the presence and absence of a predator, but significantly decreased movement and increased refuge use in the presence of a predator. Those exposed to metals demonstrated no change in activity in the presence of the trout.

The results from these experiments demonstrate that heavy metal exposure reduces survival, growth and predator avoidance of tadpoles and suggest three consequences of metal contamination. First heavy metals have direct toxic effects and in high concentrations result in tadpole mortality within a few weeks. Secondly, exposure to metals delays tadpole development and metamorphosis, which could have significant consequences in ephemeral water bodies. Finally, tadpoles exposed to metals demonstrated reduced predator avoidance behavior, which may increase predation by fish and consequently predators would consume a greater percentage of metal exposed tadpoles.

Howard et al. (date?)

In order to assess the impacts of heavy metal contamination on hatching success and larval survival on the model amphibian *Rana pipiens*, sediments and water samples were collected from three wetland areas downstream of the Banker Hill Superfund site. The samples were representative of the range of contamination levels in the assessment area. Two uncontaminated reference sites were also included in the study.

Egg masses from 5 gravid females were artificially fertilized and the average weight per egg from each female was determined in order to estimate the total number of eggs used in each of the treatments as well as account for any differences among the females. Egg masses were randomly assigned to each treatment and larval counts were made for 14 days in the treatment tanks. Water and soil samples were sent to a commercial lab for subsequent metal analysis. The data from the hatching experiment were analyzed using separate log regressions for each metal detected from the samples. The results from the regression analysis indicated a significant decrease in hatching success as the amount of heavy metal (lead, zinc or cadmium) increased in the sample. The average hatching success in samples containing no metals was estimated at 50 percent samples containing 6,835 ppm lead, 4,035 ppm zinc, and 30.5 ppm cadmium resulted in an estimated 20 percent reduction in hatching success. While there was a negative trend associated with the amount of heavy metals in water, there was no significant correlation.

Similar methods were used to examine larval survival, with 30 tadpoles randomly assigned to tanks containing sediments and water samples collected from contaminated areas and uncontaminated reference sites. Tadpoles were monitored for a total of 88 days. A Cox proportional hazards model was used to fit the data, using lead as the single explanatory variable. The resulting hazard function for the lead was found to be significantly related to the amount of lead in the sediments. The model determined that the instantaneous probability of death increased by 5.6 percent for every 1,000 ppm increase in lead concentration. The instantaneous probability of death at the highest contaminated site, 8,570 ppm, was found to be 60.5 percent greater than the uncontaminated reference site.

Tadpoles were retained from each experimental unit to be used for pathway analysis of the metals. Tissue samples were sent to a commercial lab for analysis. Results indicated a significant linear relationship between lead concentration in the sediments and lead concentration in the tissues of the tadpoles. In addition tadpoles that survived the entire 88 days had greater lead concentrations in their tissues than those that had died earlier. These two lines of evidence demonstrate the capacity for amphibians to bioaccumulate heavy metals.

3.2.1.2.4.2 Birds

Day et al. (1998)

The toxicity of lead-contaminated sediments from the Coeur d'Alene River basin was examined on captive Mute swans (*Cygnus olor*) in a completely randomized feeding experiment. Swans were fed one of two diets representing optimal nutrition and a sub-optimal diet, representing more natural nutritional conditions. One group was fed a commercial waterfowl maintenance diet with 0, 12 or 24 percent lead-contaminated sediment or a 24 percent uncontaminated sediment. A second group was fed a ground rice diet mixed with 0 or 24 percent contaminated sediments or a 24 percent uncontaminated sediment. Feeding trials included 8 swans per treatment and continued for 42 days. The swans were monitored throughout the experiment, blood samples were collected at biweekly intervals and fecal samples were collected three weeks into the experiment. At the end of the feeding study the swans were weighed, bled and complete necrospy exams were made.

Analysis for lead content indicated the sediments collected from the contaminated site at Harrison Slough contained 3950 µg/g dry weight compared to 9.7 µg/g dry weight from the Round Lake reference site. Fecal analysis indicated that experimental lead levels approximated the natural exposure of wildlife in the Coeur d'Alene River basin. Results indicated that ingestion of reference sediments had no significant negative impacts on swans, but ingestion of contaminated sediments resulted in significant indications of lead poisoning. The severity of the illness was directly related to the amount of sediment as well as the quality of the diet. While no mortality occurred during the experiment, three of the swans fed rice with 24 percent contaminated sediment were lethargic, ataxic and severely emaciated. All of the swans in this feeding group exhibited significant reductions in body weight relative to other groups. Examination of blood and tissue concentrations was indicative of lead poisoning, including increased levels of lead in the blood, liver and brain. Swans fed diets containing contaminated sediments all demonstrated reductions in hematocrit and hemoglobin, severely depressed red blood cell ALAD activity and increased protoporphyrin. Signs of lead poisoning were all dose-dependent and in all cases the toxic effects were most pronounced in the rice with 24 percent contaminated sediment group. The signs of lead toxicity observed in the experimental rice-fed group with the highest level of contamination were similar to those observed in dead wild swans collected from the Coeur d'Alene River basin, though not as severe.

Hoffman et al. (1999, 2000)

A 6-week feeding study was conducted to determine the toxic effects of contaminated sediments from the Coeur d'Alene River basin on Canada goose (*Branta canadensis*) goslings and mallard (*Anas platyrhynchos*) ducklings. Feeding treatments were based on estimated natural sediment ingestion rates. Sediments were collected from Harrison Slough in the Coeur d'Alene River basin and Round Lake, in the St. Joe River basin. Randomly selected feeding treatments included untreated control diet, 48 percent clean sediment and 12, 24 and 48 percent contaminated sediments. Similar methods were used for the ducklings, with 24 percent being the maximum sediment amount for both uncontaminated and contaminated diets. The duckling study also included a 24 percent lead acetate-clean sediment mixture as a positive control for lead toxicity. A second duckling group received the same treatments, but were fed a sub-optimal corn diet. All birds were monitored throughout the experiment and weighed on a weekly basis. Blood and tissue samples were taken at the end of the feeding trials and complete necropsies were performed. Analysis of variance and Dunnett's multiple comparison tests were used for data comparisons.

Sediments from Harrison Slough were found to contain an average dry-weight of 3449 µg/g lead and 3008 µg/g zinc. The reference sediments at Round Lake had an average dry-weight of 6.3 µg/g lead and 28 µg/g zinc. Iron and manganese were also elevated in the Harrison slough sediments. No organochlorine pesticides of PCBs were detected in the sediment samples.

Mortality occurred in two of the nine goslings in the 48 percent contaminated sediment group; all other goslings lived to the end of the experiment. Blood samples indicated increased lead concentration, high levels of protoporphyrin and decreased levels of hemoglobin and ALAD. Plasma and liver analysis indicated elevated LDH-L activity and increased hepatic lipid peroxidation, indicative of cellular damage, and increased hepatic glutathione concentrations, indicating alteration of enzymatic activity.

One of the 15 ducklings in the lead acetate treatment died prior to the end of the experiment, but no other mortality occurred during the feeding trials. Growth was significantly reduced in the lead acetate group relative to the clean sediment control. No differences in growth were observed among the other groups. As with the goslings, blood and tissue samples demonstrated evidence for lead toxicity such as increased lead concentrations in the blood and tissues, as well as decreased hematocrit, hemoglobin and ALAD. Protoporphyrin and LDH-C levels were significantly increased. Ducklings receiving the sub-optimal diet and high does of contaminants exhibited significantly reduced growth relative to the controls and exhibited generally increased toxic responses.

In all feeding trials the relationship between lead contamination in the diet and subsequent accumulation of lead in the blood and tissues was dose-dependent. High lead concentrations in ingested sediments led to adverse physiological changes resulting in decreased growth and increased the likelihood of juvenile mortality. The effects of lead toxicity were intensified under sub-optimal ~~dietary~~ conditions, suggesting that under natural conditions the adverse effects are likely to be intensified.

Heinz et al. (1999)

A series of feeding studies was conducted to examine the bioavailability and toxicity of sediments to mallards (*Anas platythynchos*). Sediment levels were based on field-derived estimates for sediment ingestion by waterfowl. Reference sediments were collected from Round Lake in the St. Joe River and contaminated sediments were collected at Harrison Slough in the Coeur d'Alene River basin. The sediment analysis indicated mean concentrations of 3,400 µg/g lead and 3,000 µg/g zinc at Harrison slough, compared to 6.3 µg/g lead and 28 µg/g zinc at Round Lake. No pesticides or PCBs were detected in the sediments.

In the first experiment the mallards were fed for 10 weeks on a diet of pelletized commercial duck food which included no sediment, 24 percent uncontaminated sediment, and 3, 6, 12, and 24 percent contaminated sediments. The average amount of lead included in the feed mixtures was reported at 2.5 µg/g for the 24 percent uncontaminated sediments and 103, 207, 414, and 828 µg/g for the 3, 6, 12, and 24 percent contaminated sediments respectively. All birds were monitored throughout the study. Weight measurements were recorded on weekly intervals, and blood samples were taken at 5 and 10 weeks. Feces was sampled during the eighth week of the study. At the end of the study period necropsies were conducted on all birds. Analysis of variance and Tukey's multiple comparison test were used for data analysis. Correlation analysis was used to test the relationship between blood lead concentrations and tissue concentrations.

Fecal analysis indicated that nearly all of the sediment included in the food pellets was ingested by the mallards. There was no overall difference in weight loss among treatments. One of the mallards in the 24 percent contaminated sediment treatment appeared weak and subsequently died during the last week of the experiment. The necropsy of this animal found several clinical signs of lead poisoning, including atrophy of the breast muscle, light green staining of the feathers around the vent, and a bright green gizzard lining. None of the other birds in this treatment showed overt clinical signs of lead poisoning, but necropsies revealed clinical evidence of toxicity. Minimal clinical signs were observed in one bird from 12 percent and one from the 6 percent contaminated sediment groups at necropsy. At the highest lead concentration there was a significant reduction in hemoglobin and ALAD as well as increased protoporphyrin. Lead concentrations in tissues and feces increased with increased levels of lead in the blood.

A second 5-week feeding experiment, using the same experimental design and sediment sources, examined the toxic effects of higher sediment concentration in mallard diets. Treatments included a commercial duck food mash with no sediment, 48 percent uncontaminated sediments, and 24 and 48 percent contaminated sediments. Lead concentrations were 8.7, 642 and 1284 μg/g for the uncontaminated, 24 percent and 48 percent treatments respectively. Blood and fecal samples were collected at the end of the experiment and complete necropsies were performed on all birds.

Based on fecal analysis lead ingestion was lower than expected, due to food washing by the mallards to remove sediments. None of the birds exhibited overt clinical signs of lead poisoning; however, necropsies revealed that all of the 48 percent contamination group and half of the 24 percent contamination group exhibited clinical signs of toxicity. Hematocrit, hemoglobin and ALAD were all significantly lower and increased levels of protoporphyrin were observed.

The third experiment was designed to test the toxicity of lead under nutritionally poor diet conditions. The same methods as the previous studies were used in the experiment with the exception of the mallard diets and length of feeding trials, which in this study lasted for 15 weeks. Experimental diets included 24 percent uncontaminated sediment mixed either with commercial duck food mash or ground corn, and 24 percent contaminated sediment mixed with commercial food or ground corn. Additional sediments were collected from the same sites as were used in the previous studies. Analysis of the lead concentration indicated a mean of 4,000 μg/g for the Harrison Slough site and 9.7 μg/g for the Round Lake site. Lead concentrations in the feed mixtures were found to be 3.0 and 3.7 μg/g for commercial feed and corn with 24 percent uncontaminated sediments, and 954 and 869 μg/g for the commercial feed and corn with 24 percent contaminated sediments. Blood samples were taken at 7 and 15 weeks and fecal samples were taken after five weeks. Complete necropsies were performed at the end of the experiment.

Sediment ingestion was observed to be less than expected in this experiment, again due to food washing by the mallards. There were no weight differences between the commercial feed treatments, but by the third week of the study both corn-fed groups weighed significantly less than the commercial feed groups. By week nine there was a significant weight difference between the contaminated sediment and corn and the control corn treatment groups. Four of the birds fed contaminated corn died prior to the end of the experiment, but only one exhibited any overt signs of lead poisoning prior to death. A fifth mallard was overtly weak towards the end of the study period, but did not die. Necropsies showed all of the birds in the lead-contaminated corn group to be emaciated, and all showed clinical signs of lead poisoning. Four of the birds given lead-contaminated commercial feed showed clinical signs of poisoning. Hemoglobin was significantly lower in the lead-contaminated corn-fed group relative to the control corn-fed group. Protoporphyrin was higher and ALAD was depressed in both lead-contaminated groups.

A clear dose-dependent relationship between sediment ingestion and lead concentration in the blood and tissues was observed throughout the experiment. Despite the fact that sediments were removed from the diets in experiment two and three, the lead levels observed in the blood and tissues were found to be directly correlated with the amount of lead ingested. Results also demonstrated that a nutrient-poor diet enhances lead uptake and storage in tissues. As the results found in this study are consistent with lead levels reported for dead waterfowl collected from within the Coeur d'Alene River basin, the levels used in the experiments are thought to be representative to contamination levels ingested by wildlife. Results support the conclusion that consumption of lead-contaminated sediments bioaccumulates in blood and tissues with the potential for harmful and ultimately fatal consequences for waterfowl.

Connor et al. (1994)

Sediments collected from Killarney Lake were used in a 3-week feeding trial to test the bioavailability of lead from contaminated sediment in northern bobwhites (*Colinus virginianus*). One group of bobwhites was fed a standard poultry feed, and a second was given the same feed with 8 percent sediment added. The birds were weighed at the end of each week and liver and kidney samples were examined at the end of the experiment.

No overt indications of lead poisoning were observed, and no differences in body weights were detected. Accumulation of lead was observed in the tissues below levels indicative of clinical lead poisoning, and below the "background levels" recorded in wild populations. Blood concentrations in the treated birds were, however, well above the clinical level indicative of lead poisoning. It was suggested that the optimal diet and thermal conditions may have reduced the negative effects of the lead accumulation in bobwhites.

3.2.1.2.4.3 Mammals

Maddaloni et al. (1998).

Using stable isotope dilution methods and extensive characterization of soil factors that impact bioavailability, absorption of soilborne lead was measured in adult humans. Soil samples were obtained from the Bunker Hill Superfund site, and were found to contain an average concentration of 2,240 ppm lead. After soils were sieved the concentration increased to 2,924 ppm. Test subjects were randomly assigned one of two groups, one group would skip breakfast and consume only a liquid lunch while the other group would eat three standard meals a day. **All subjects ingested soil containing 250 μg lead / 70kg body weight.** Total amount of soil administered for each group (72.9 and 82.9 mg) approximated the daily range of incidental soil ingestion by adults. Blood and urine samples were collected over a 30-hour period following ingestion of the soil.

The mean lead concentration in the fasted group increased by 1.01 μg/dl whereas the normal diet group experienced an increase of only 0.3 μg/dl. It was estimated that 26.2 percent of the lead in the soil was absorbed in the fasted group, while the normal diet group absorbed an estimated 2.52 percent.

Burrows et al. (1982)

Feeding trials were conducted using horses to assess the possibility that lead toxicosis observed in the Coeur d'Alene River basin was the result of consumption of lead-contaminated hay. Horses were randomly assigned to one of three feeding treatments. The first group was fed grass hay grown in the area of the ore smelter, which was found to contain 423 mg/Kg lead and 10.8 mg/kg cadmium. A second group was fed grass hay from the Moscow, Idaho area containing 21.2 and 1.7 mg/kg bodyweight, lead and cadmium respectively. This group was given lead acetate trihydrate on a daily bases to match the lead dosage of the first group. A third group was fed uncontaminated hay. Horses were weighed and blood samples were collected throughout the duration of the study.

Survival of the group one horses ranged from 84 to 100 days. The estimated daily metal consumption was 7.4 and 0.18 mg/Kg for lead and cadmium respectively. After 11 weeks physical condition began to deteriorate, weight loss eventually became severe, and incoordination, loss of muscular control in the lips and rectal sphincter, and CNS depression were observed. On average death occurred 16 days after the onset of symptoms of toxicosis. Estimated daily consumption of lead was slightly higher for the group two horses, 10 mg/kg body weight, and survival ranged from 113-304 days. Clinical signs of toxicosis were similar to those observed in group one, but the timing was more variable and death occurred on average 52 days after signs were first observed.

Prior to the onset of clinical toxicosis a 30 percent reduction of PVC was observed accompanied by the appearance of n-RBC. While these changes are indicative of lead poisoning, they did not reflect the severity of the disease. Examination of lead concentrations in the blood found the group one horses (0.3 μg/ml) had slightly lower concentrations than group two (0.5 μg/ml). In both groups there was no detectable increase in lead concentrations with the onset of the clinical signs of toxicosis and impending death. Tissue analysis indicated similar lead concentrations for both group one and two, which were significantly higher than the control group. Tissue concentration for cadmium was highest in group one, but also was significantly higher than the control in group two.

The differences observed between groups one and two suggested greater severity of the disease in horses fed hay grown on contaminated soils. It was suggested that this difference might be due to the effects of multiple metals in the contaminated hay.

3.2.1.3 Site-Specific Field Surveys

3.2.1.3.1 Fish

Fish population estimates have made based on sampling in reference and assessment areas in CSM Units 1 and 2 by R2 Resource Consultants (R2) (R2 Resource Consultants 1995a, 1996a, 1997a) and Stratus Consultants, Inc. (Stratus 1999d) (electronic data provided by R2 Resource

Consultants, and summary report by Stratus 1999d), and by the State of Idaho as part of the Beneficial Uses Reconnaissance Program (BURP) (raw data forms provided by Geoff Harvey, IDEQ). The fish population data collected by R2 and Stratus was based on multiple-pass electro-shocking, while the data collected by the State of Idaho was generally based on single pass electro-shocking. The BURP data were converted to estimated populations equivalent to multiple pass estimated using the conversion of Armour, et al. (1983).

Metric scoring is based on the estimated trout density (including native west-slope cutthroat, and introduced rainbow, brook and brown trout), expressed in fish per square meter (m^2), and the presence or absence of sculpins. Sampling was did throughout the SFCDR, its tributaries, and on the St. Regis River at locations selected and distributed to provide a representative population estimate (Reiser 1999, Stratus Consulting 1999a).

A trout density of 0.1 fish per square meter was selected as a breakpoint between the good and moderate metric ranking based on evaluation of fish populations in least impacted reference streams. The presence or absence of sculpins is also selected as a metric breakpoint, on the basis of their sensitivity to metals pollution and habitat disturbance. Adult home ranges of sculpins are generally less than 150 meters, and often much less (<50 meters). As such, they are subject to localized habitat quality issues and their absence is indicative of degraded habitat (Hendricks 1997, Reiser 1999).

- Metric score 3 (excellent): Trout density >0. 11m^2, sculpins present.
- Metric score 2 (good): Trout density >0, <0. 11m^2, sculpins present.
- Metric score I (medium): Trout present, sculpins absent.
- Metric score 0 (poor): No fish present.

Trout were present in all reference stream locations sampled (Table 3.2.1.3-1). Metric scores for reference stream segments were 2 or 3, with the exception of one sampling event in 1994 on the lower Little North Fork when sculpins were not captured and the metric score was 1. Sculpins were captured at that location in 1995, and the metric score was 2.

Metric scores for fish were generally from 0 to 2 in the assessment areas, with some notable exceptions: Beaver Creek and the upper South Fork of the Coeur d'Alene River (the Morning District near Mullin, and upstream), where metric scores of 2 to 3 were observed (Table 3.2.1.3-2) had scores comparable to, or better than the associated reference areas. The BURP assessment locations in Beaver Creek are well downstream of the Carlisle Millsite, while the elevated concentrations of metals in Beaver Creek are above and just below the Carlisle Millsite, so the scores from Beaver creek may not reflect conditions in the most affected area.. The metric scores for fish indicate that fish populations in most assessment areas are reduced, or absent in some places, compared to reference streams. The most seriously affected areas are Canyon Creek, Segment 5, and Ninemile Creek, Segments 1, 2, and 4, where fish were not captured by electroshocking.

Comparable fish population data are not available from CSM Units, 3, 4, and 5; due in part to the large size of the rivers and lakes in those CSM Units. However, studies of the Spokane River (CSM Unit 5) have indicated the presence of good rearing habitat for trout (Kleist 1987) with limited spawning habitat (Johnson 1997). Because of the size of the Spokane River, population density has been measured (Bennett and Underwood 1988) using electro-shocking methods that differ somewhat from those used in the upper Coeur d'Alene River basin. Population estimates were stated as 19,029 trout per their 7.9 km study reach (presumably excluding fry). Assuming a width of 50 to 75 m, that would be 0.032 to 0.048 trout per square meter (Bennett and Underwood report 5.2g per square meter, but do not provide the basis for determining how many square meters are present in their study areas). In any case the metrics used to evaluate the upper basin streams would not apply in the much larger Spokane River. Bennett and Underwood (1988) estimated that the annual mortality of trout in their Spokane River study area was about 70 percent, with fishing mortality contributing up to 10 percent. The remainder of the mortality was attributed to post-spawning mortality and effects of metals.

Rabe 1999 report?

3.2.1.3.2 Benthic Macro-Invertebrates (Don)

Data were obtained from macroinvertebrate sampling from CSM Units 1 and 2 done in 1998 in the SFCDR, NFCDR, St. Joe River, and tributaries of these systems for the BURP project (IDEQ 1999) and by ~ Resource Consultants in 1996 (R2 Resource Consultants 1996a; Stratus Consulting 1999e 1999f). Counts based on less than three replicates per location per sampling event were not included in this evaluation because of low certainty in the results. An additional source of data being from studies done by the U.S. Bureau of Mines for the U.s. Forest Service (McNary, et al. 1995).

Species richness of the benthic macro-invertebrate community, expressed in the number of taxa collected at a sampling location, is one of several macro-invertebrate metrics used to indicate the ecological condition of Pacific Northwest watersheds (Bennet and Fisher 1989; Hoiland and Rabe 1991;R2 Resources Consultants 1997c; Stratus Consulting 1999d). Usually species richness is evaluated in conjunction with these other metrics to form an evaluation of ecological conditions. However, different sampling methods were used in the three data sources available for this analysis, which invalidated comparison of the majority of the metrics. Species richness data was comparable, and in general, higher macro-invertebrate species richness is indicative of better ecological condition in Pacific Northwest watersheds (Hoiland and Rabe 1991).

Two separate sets of macro-invertebrate metric scores were developed CSM Unit 01 and 02 segments from species richness counts taken from Rosgen (1994) type B and Rosgen type C reference streams. For each set, the mean number of taxa and the standard deviation were calculated. Two standard deviations below the mean was established as the breakpoint between "good" and "medium" conditions. Eight or fewer macro-invertebrate species was established as the breakpoint between "medium" and "poor" conditions, based on observed numbers of metals and disturbance tolerant taxa (e.g., ***Chironomidae)*** in degraded areas. The numbers of taxa and summary statistics for the numbers of taxa from Rosgen type B and type C streams are shown in Tables3.2.1.3-3 and 3.2.1.3-4, respectively.

Numbers of taxa for the arrayed reference and assessment areas are shown on Table 3.2.1.3-5. The reference stream sections all have metric ratings of 3, as do some of the assessment stream sections (Table 3.2.1.3-5). Assessment stream sections with metric ratings of 1 (poor) included lower Canyon Creek (Segment 05) Lower Moon Creek (Segment 02), Upper Ninemile Creek (Segment 01-location uncertain), and the South Fork of the Coeur d'Alene River near Enaville and near Smelterville (CSM Unit 2, Segment 2).

In general, the metric for taxa richness indicate that more assessment stream sections are comparable to reference stream sections than was indicated by the metrics for fish (Table 3.2.1.3-2).

Benthic invertebrate communities were studied in Coeur d'Alene Lake by Winner (1972) and Ruud (1996). Winner (1972) observed a strong dominance by Chironomids (51-75 percent) and Oligochaetes (26-49 percent), and species of the subfamily Chironominae (dominated by *Microspecta* sp. and *Chronimus* sp.) comprised the majority (73 percent) of the Chironomids. However, Winner (1972) did not find a relationship between sediment metal concentrations (e.g., Zn concentrations up to 7,000 mg/kg) and the distribution of Chironomids or Oligochaetes.

Ruud (1996) detected significant differences in the proportions of dominant taxa of profundal communities (20 m to 40 m depths), and sublittoral communities (5 m to 10 m depths) between Coeur d'Alene Lake and Priest Lake, Idaho, an oligotrophic lake of similar size, flow, and parent geology. Profundal communities of Priest Lake were dominated by Chironominae *(Microspectra* sp. and *Chironomus* sp.) and Sphaeriidae, whereas Coeur d'Alene Lake profundal communities were dominated by Nematophora, Tricladidae, and Oligochaetae. Sublittoral communities in Priest Lake were dominated by Chironominea and Tanypodinae, whereas Coeur d'Alene Lake sublittoral communities were dominated by Amphipoda, Isopoda, Tanypodinae, and Oligochaetae. Ruud (1996) observed a negative correlation between Zn concentrations in water and total abundance, total biomass, taxa richness, and mean diversity, as well as between Pb concentrations in water and total abundance and total biomass. However differences in abundance of *Chironominea* and total abundances and biomass of benthic invertebrates did not show a clear relationship to metals concentrations, especially in deeper water where metals concentrations are generally higher.

3.2.1.3.3 Terrestrial Plants

One field survey of the terrestrial plants in the Coeur d'Alene River basin was conducted. The summary of this investigation follows.

A riparian resources injury assessment of the Coeur d'Alene River basin (Hagler-Bailly 1995), and an evaluation of adverse effects to riparian resources based on this assessment (and LeJeune and Cacela 1999) were conducted. Specifically, field studies were conducted to determine whether floodplain soils and riparian vegetation have been adversely affected by releases of hazardous substances, including cadmium, lead, and zinc. This involved collection of soils for analysis of metals and other soil characteristics, as well as collection of vegetation measurements to characterize vegetation community composition and structure. Soil and vegetation samples were collected from assessment reaches (areas of known mining-related disturbances) on Canyon Creek (CSM Unit 1) between Burke and Gem, ID, from the East Fork of Ninemile Creek (CSM Unit 1), from the South Fork of the Coeur d'Alene River (CSM Unit 1 and CSM Unit 2) between the Canyon Creek confluence and Enaville, ID, and from the main stem of the Coeur d'Alene River and lateral lakes area (CSM Unit 3 and 4) between Enaville and the mouth of the river at Harrison, ID. Reference reaches (areas presumed to be unexposed) included Canyon Creek upstream of Burke near Sawmill Gulch, Ninemile Creek upstream of the East Fork Ninemile Creek confluence, and the Little North Fork Coeur d'Alene River. During sampling it was discovered that the area of Canyon Creek assumed to be unexposed had, in fact, been exposed to mining-related releases of hazardous substances.

Soil samples at each site were a composite of five subsamples collected from subunits selected to correspond with vegetation measurements made within a circle of 10 m radius, and to be representative of all areas of the 10 m radius circle in equal proportion. Sub-samples of equal volume were collected from the 0-15 cm depth at the site center point and at the four vertices of a square surrounding the center point. Also within the 10 m radius circle, the following vegetation parameters were visually estimated: most prevalent cover type (e.g., coniferous forest, deciduous forest, coniferous shrubland, deciduous shrubland, grassland/forb pasture, wetlands, bare ground, dead vegetation), structural habitat layers present (e.g., terrestrial sub-surface, understory, shrub midstory, tree canopy, and tree bole), and approximate areal coverage of each structural layer. The species, cover, and height classification of all plants intercepting a north-south 10 m line transect centered at the midpoint of the site were recorded, and cover and species richness (number of species) was calculated by site for all vegetation, and by herbaceous, shrub, and tree height classes. In total, 107 sites were sampled, including 63 sites in the upper basin, and 44 sites in the lower basin. Of the upper basin sites, 40 were located downstream of major mining operations, and 23 were at locations presumed to be upstream of mining influence reaches or on unmined drainages. All sampling was conducted in late-August, 1994.

Analysis of soil samples indicated that exposed floodplain soils from Canyon Creek, Ninemile Creek, and the South Fork Coeur d'Alene River have significantly greater concentrations of hazardous substances than reference area soils. Additionally, of the 107 sites sampled, 78 percent were classified as predominantly vegetated and 22 percent were classified as predominantly bare. Bare ground was the dominant cover type at 100 percent of the Canyon Creek assessment sites, 80 percent of the Ninemile Creek assessment sites, and 50 percent of the South Fork Coeur d'Alene River sites. In contrast, vegetated cover types were dominant at 100 percent of the reference sites. Significant reductions in percent cover of litter, herbaceous cover, and shrub cover were observed at Ninemile Creek, Canyon Creek, and South Fork Coeur d'Alene River assessment sites relative to reference sites. Tree canopy cover at Canyon Creek and Ninemile Creek did not differ from reference areas, but was reduced at South Fork Coeur d'Alene River. These reductions indicate significant reduction in the vertical complexity of vegetation communities at assessment sites.

The species richness survey identified 172 vascular species, 140 taxa in the herbaceous layer, 54 taxa in the shrub layer, and 8 species in the tree layer. Herbaceous totals do not include spring ephemeral species because sampling occurred in late summer. Sites on reference reaches of the upper basin had significantly greater overall species richness and species richness in the herbaceous and shrub layers than sites on assessment reaches, while tree species richness was low at all sites. The numbers of species in the tree, shrub, and herbaceous layers at assessment reaches were lower than the numbers in these layers at reference sites. Specifically, 39 species were recorded at Canyon Creek reference areas compared to only 2 species at Canyon Creek assessment sites. A severe lack of species richness was also observed at Ninemile Creek (14 species compared to 52 species at reference sites) and South Fork Coeur d'Alene (35 species compared to 106 species at reference sites). Analysis of the number of structural habitat layers indicated that assessment reaches were vertically simple (primarily 0 to 3 layers) compared to the more vertically complex (2 to 5 layers) reference areas.

Correlation analysis indicated that percent cover of vegetation by layer, number of species by layer, and number of habitat layers are significantly negatively correlated with concentrations of arsenic, cadmium, copper, iron, lead, manganese, and zinc in the upper basin. Additionally, percent cover of bare ground was positively correlated with metals and arsenic concentrations. A significant negative relationship between cover in the herbaceous layer and all metal and arsenic concentrations was observed in the lower basin. Principal components analysis (PCA) was performed in order to evaluate the multivariate relationships between soil chemical quality and the composition and structure of field vegetation. Ordination along two axes explained 91 percent of the variation in the data set. Reference and some lower basin sites occurred at the origin, while the assessment sites were scattered in the direction of increasing total metals concentrations and increasing variability in metals concentrations. Cluster analysis was used to classify sites by similarity of vegetation structure. When the results of PCA and cluster analysis were compared, all but two upper basin reference sites were categorized as structurally complex and low metals concentrations. In contrast, all but two upper basin assessment sites were categorized as structurally simple, and all had high metals concentrations.

The report concludes that reductions in vegetation cover are a result of toxic levels of hazardous substances, and that these reductions have adversely impacted the ecological functions (e.g., riparian habitat for biological receptors, growth media for plants and invertebrates, carbon storage, nutrient cycling, soil/bank stabilization and erosion control) of the river basin. Furthermore, they estimate that 1,522 acres (616 ha), or 80 percent of the available non-urban floodplain along the South Fork Coeur d'Alene River south of the Canyon Creek confluence, Canyon Creek, Ninemile Creek, Moon Creek, and Pine Creek, is barren or substantially de-vegetated.

3.2.1.3.4 Amphibians

One amphibian study involving a spring breeding survey and a summer larval survey has been conducted in the Coeur d'Alene River basin. The summary of this study follows.

A field study was conducted to estimate the amphibian species assemblages and relative abundance in wetlands in the lower Coeur d'Alene River basin (Howard et al. 1998?). The study area included wetlands and lateral lakes along the CDAR from Cataldo River to its confluence with Lake Coeur d'Alene (CSM Units 3 and 4). Results from this area were compared to reference areas located within the St. Joe's River and St. Maries River systems. Sampling to detect amphibian adults and egg masses occurred during the spring breeding season (26 March to 31 May), and a summer larval survey was conducted from 12 June to 30 July. The spring survey included a standard visual encounter survey and an audio survey at 20 0.5 km segments of land along the Coeur d'Alene River and 9 0.5 km segments along the SJR. Observers also recorded the wetland habitat class (e.g., open water, wetland emergent, wetland scrub shrub) between the observer and the shoreline, and the terrestrial vegetative cover type (e.g., upland herbaceous, scrub shrub, tree, cropland, or barren/slickens) and percent cover within 1 m of the shoreline. Water depth was recorded at each listening station. Summer surveys included quantitative sampling of larval amphibians using traps, seines and dipnets at 55 100 m sampling segments along the Coeur d'Alene River and 40 100 m sampling segments along the St. Joe River. Additionally, observations of amphibians sighted by field personnel were recorded.

Habitat differences were quantified through the application of Habitat Suitability Index (HSI) Models. An HSI model for ranid frogs and one for all other amphibians were constructed. Habitat features used in the both models included the degree to which the shoreline is vegetated, the density and total amount of aquatic vegetation, and water depth. Upland habitat measurements were added to the model for all other amphibians. An assessment of the significance of environmental variables in explaining variation in amphibian counts was performed using a generalized linear model technique. This model was used to relate the logarithm of the expected amphibian count to a linear combination of environmental covariates (e.g., cloudiness of the sky, time of day, wind speed, percent open water, water depth, percent emergent vegetation, HSI, and either assessment or reference).

During the breeding season survey, cloudiness, percent open water, water depth, and percent emergent vegetation were all significantly related to the number of ranid amphibians seen at the $p=0.1$ level or less. The basin designation (assessment or reference) did not account for a significant amount of the variation in average count; however, after adjustment for other covariates in the system, there was a trend toward more ranid amphibians in the reference basin. Results for other amphibians were similar, despite a slightly different model which included the HSI and wind speed. All factors except HSI, wind speed, and basin designation contributed significantly to the number of other amphibians. As with ranids, when covariates in the system were adjusted, basin designation showed a trend toward more other amphibians in the reference basin than in the assessment basin. HSI distributions indicated that the majority of sites sampled in reference and assessment areas had relatively low habitat suitability for both ranid and other amphibians based on the HSI model. In fact, habitat for ranids and other amphibians appeared better in the assessment area, with several sites having an HSI for ranids of > 0.75.

For the summer season survey, 57 and 14 percent of reference sites with amphibians present in the breeding season contained ranids and other amphibians, respectively. Ranids and other amphibians were observed at 55 and 36 percent, respectively, of assessment sites with amphibians present during the breeding season. Summer ranid abundance was significantly ($p<0.1$) related to air temperature, water temperature, and ranid HSI. Basin membership was also significantly related to number of ranids at the $p=0.13$ level. For all other amphibians, air temperature, water temperature, cloudiness, non-ranid HSI, and basin membership were all highly significantly ($p<0.001$) related to the number of other amphibians. Finally, the HSI distribution for the summer season indicated that both reference and assessment areas had low habitat suitability for ranid and other amphibians, although the assessment area appeared to have better habitat (several sites with an HSI >0.5).

In summary, no significant differences in the abundance of ranid frogs and other amphibians was observed between the St. Joe and Coeur d'Alene River basins, although there was a trend for more amphibians in the reference areas during the spring survey. In general, the authors attribute the low abundance in reference areas to poor habitat suitability. They further indicate that similar amphibian abundance in assessment and reference areas despite better habitat suitability in the assessment area suggest some factor other than habitat may be reducing the number of amphibians in the Coeur d'Alene River basin.

3.2.1.3.5 Birds and Mammals

The following two reviews summarize the available biological reconnaissance and mortality reports for the Coeur d'Alene River basin. Eighteen site-specific studies including 10 waterfowl, 3 raptor, 2 passerine, and 3 mammal studies are also summarized.

Audet 1997

A Coeur d'Alene River basin natural resource damage assessment biological reconnaissance investigation was conducted (Audet 1997). This study was undertaken primarily to summarize and evaluate published and unpublished information regarding the exposure of wildlife in the Coeur d'Alene River basin to Pb (and other contaminants) in order to identify documented biological injury from Pb contamination in the basin. Eighty-four documents specific to fish and wildlife investigations in the Coeur d'Alene River basin, and 116 other relevant documents, were reviewed. In addition, limited new sampling of plants, invertebrates, fish, birds, mammals, and waterfowl fecal material was undertaken from the Coeur d'Alene River basin, and from a nearby uncontaminated reference basin (St. Joe River). Collected samples were analyzed for Pb and other metals. The study design, and methods of sample collection and analysis were appropriate to the objectives of the study. And can be reasonably relied upon to generate valid results. Results of the literature review indicate that physiological injury including mortality attributed to metal – usually PB - toxicity in several species of birds and mammals in the Coeur d'Alene River basin has been reported over the years. Species reported to have been exposed to elevated levels of contaminants, and/or to have suffered injury from exposure to contaminants in the Coeur d'Alene River R basin include waterfowl, especially tundra swans, Canada geese, and mallard ducks; floodplain songbirds; birds of prey; and mammals including mink, vole, and deer mouse (summarized in Table 6-6, LeJeune et al. 1999). Results of biological sampling indicate that Pb concentrations in biota from the Coeur d'Alene River basin are significantly elevated compared to the St. Joe River basin for a number of species, including aquatic plants, brown bullhead (fish), song sparrows, robins, and various waterfowl. Based on the review of this study, and consistent with the results of the study, the reviewer concluded that, historically, biological injury to biota from the Coeur d'Alene River basin has been frequently documented; and that present day concentrations of Pb measured at various trophic levels of the terrestrial and aquatic environment of the Coeur d'Alene River basin are comparable to Pb concentrations reported in previous studies.

Audet et al. 1999(8?)

Between 1992 and 1997, a wildlife use and mortality investigation in the Coeur d'Alene River basin was conducted by Audet et al. (1999). This study was undertaken to determine the extent of waterfowl use and wildlife mortality in the Coeur d'Alene River basin, in comparison to the St. Joe River basin reference area. Between 1994 and 1997, a combination of aerial and ground surveys were conducted in both the Coeur d'Alene River and St. Joe River basins to estimate numbers of tundra swans, Canada geese, and mallard ducks that utilize these areas for feeding, nesting, loafing, or resting. Between 1992-1997, wildlife carcasses found serendipitously or through superficial searches were collected and submitted for necropsy examination. In 1995-97, organized carcass searches were conducted over a total of about 5700 ha within the Coeur d'Alene River basin, and over about 1900 ha within the St. Joe River basin. Carcasses were necropsied by wildlife pathologists at the National Wildlife Health Center, in Madison, Wisconsin. Liver tissue samples, and samples of material recovered from the digestive systems of the collected carcasses were analyzed for Pb by atomic absorption spectrophotometry, and by inductively coupled plasma emission spectrophotometry. The study design, and methods of sample collection and analysis were appropriate to the objectives of the study, and can be reasonably relied upon to generate valid results. Results of surveys indicate extensive waterfowl use of wetlands of the Coeur d'Alene River and St. Joe River basins for feeding. For carcasses recovered from the Coeur d'Alene River basin (n = 311), Pb poisoning was the greatest single cause of sickness or death. In the vast majority of birds diagnosed as Pb poisoned, very few (< 10 percent) had evidence of ingestion of metallic Pb artifacts (shot pellets, or fishing sinkers). Concentrations of Pb in the esophageal or proventricular contents of tundra swans, Canada geese, and mallards that died of Pb poisoning without the presence of Pb artifacts was positively correlated to lead concentrations in the sediments from feeding areas within the units where the carcasses were found. Based on the review of this study, the reviewer found that the author's conclusion that Pb from sediment ingestion was the primary source of toxic levels of Pb to which waterfowl on the Coeur d'Alene River basin are exposed, to be justified. The authors further concluded that, in the absence of effective remediation, Pb poisoning due to the ingestion of contaminated sediments is expected to continue in Coeur d'Alene River basin. This conclusion is reasonable, and in my opinion is justified based on the results of this and previous studies.

lifted out of an expert report (Audet?)

3.2.1.3.6 Waterfowl

Ten site-specific field studies on various waterfowl including tundra swans, wood ducks, mallards, and Canada geese were conducted in the Coeur d'Alene River basin. The summaries for these studies follow.

Chupp and Dalke 1964

Plant and waterfowl samples were collected and periodic counts were made of ducks, geese, swans and coots along a 4.5 mile route of the Coeur d'Alene River in order to estimate the mortality rates and lead exposure of waterfowl in the given area. The study area covers approximately 15 miles of the Coeur d'Alene River from Killarney Lake to the mouth of the river in Harrison, Idaho. Field investigations begun in 1955 noted some mortality among waterfowl. Birds found dead were collected and the stomach contents, as well as liver and bone were removed for further analysis. Soil and plant materials were also collected for analysis.

The authors' review of literature in regard to waterfowl mortality revealed that mortality of birds in the area was noted as early as 1924. One of the largest losses of waterfowl occurred during the spring in 1953 and 1955. Weather forced the birds to stay longer than usual. After investigation and research it has been concluded that a majority of these moralities were from lead poisoning. Collections of aquatic plants and oat samples from the area in 1955 showed large lead concentrations (1,500 – 3,700 ppm). All the swans that were sick or dead exhibited similar symptoms. They got sick 3-4 weeks after arrival and did not attempt to keep up with the rest of the flock. The sick swans all seemed listless and isolated, often being found on shores or in backwater areas. Muscle fatigue was noted as well as low body temperature and weight. The gizzard was noted as malfunctioning or paralyzed. The livers were discolored and looked decomposed. Five of the sick swans were analyzed and livers showed large concentrations of lead (12-50 ppm, wet weight), copper (5-72 ppm), and zinc (3.5-29 ppm).

The authors concluded from their literature reviews and field studies that contamination of the valley by mine wastes was the prime cause of the long history of bird die-offs along the Coeur d'Alene River.

Benson et al. 1976

Analysis of 13 dead swans found in the Coeur d'Alene River basin was performed in order to determine their cause of death. The area of study was Mission Lake between Kellogg and Coeur d'Alene, Idaho. This area has been noted as highly contaminated due to mining practices within the region. Dead swans were collected in June of 1974. They were autopsied and tissue samples were frozen for further analysis. Lead shot was found in only two birds. Lead levels in these swans was analyzed and high concentrations ($\times = 40.38$ ppm) were found in the bone of all swans except one, which had high levels in the spleen. Liver Pb concentrations ranged from 7 to 43 ppm with a mean level of 23.31 ppm. During this study, swans dying in the Mission Lake area showed typical signs associated with lead poisoning such as lead residue in bones, emaciation, enlarged gizzards and a greenish cast of the intestinal tract. The authors concluded that the lead levels in these birds were high enough to cause mortality, and suggested that ingestion of lead contaminated vegetation was responsible for the mortality observed.

Blus et al. 1991

Blood samples were drawn from migrating tundra swans captured in swim-in traps between February and April 1987 in lakes and marshes along the Coeur d'Alene River (Blus et al. 1991). Aliquots of the blood samples were analyzed for lead, hemoglobin, and δ-aminolevulinic acid dehydratase (ALAD), and protoporphyrin. The five trapped birds that had the lowest blood lead levels (0.47 to 0.60 μg/g) had average values for hemoglobin (19 g/dl), hematocrit (40 percent), ALAD (54 units), and protoporphyrin (42 μg/dl) that were markedly different from both those of the 4 moribund birds and the 11 trapped swans that had blood lead levels of 0.64 to 9.6 μg/g and mean values for hemoglobin (18 g/dl), hematocrit (47 percent), ALAD (24 units), and protoporphyrin (94 μg/dl). Control values were unavailable for the tundra swans.

The number of dead swans observed was also recorded from 1987 to 1990 for Lake Coeur d'Alene and other relatively uncontaminated areas near the St. Joe River and Round Lake. Autopsies of 43 carcasses identified symptoms of lead poisoning such as bile-stained or sloughing gizzard pads (found in 80 percent), partial or complete impaction of the gizzard (59 percent), enlarged gall bladders containing dark-green viscous bile (93 percent), severe emaciation (84 percent), and reduction or absence of coronary fat (72 percent). Only 13 percent of the apparently lead poisoned swans had ingested lead shot in their gizzards. The five birds from the St. Joe River and Round Lake had no signs of lead toxicosis, with the exception of one of the birds with green-stained gizzard pads and no ingested shot were noted.

The livers and kidneys of 41 carcasses were further analyzed to determine the levels of Pb and Cd, respectively. Lead levels were detected in only 3 of the 5 livers in the birds from the uncontaminated sites with a maximum concentration of 1 μg/g (wet weight). Of the 36 livers from the contaminated area that were analyzed for lead, 32 contained levels considered lethal (6.4 - 40 μg/g) and 4 contained nonlethal levels (nondetectable-2.3 μg/g). Cadmium levels were low for birds found in both the contaminated and uncontaminated sites (0.15-0.41 μg/g in kidney tissue). Lead concentrations in the ingesta (mostly plant material) from the upper GI tract were also determined. Ingesta from nearly all Pb poisoned birds were high (maximum of 312 μg/g).

Blus et al. 1993

A field study in the Coeur d'Alene River system was conducted in 1986 and 1987 by Blus et al. (1993) to determine the accumulation of Pb and Cd in wood ducks and the effects on physiological characteristics and reproductive success of the exposure. The study area consisted of the contaminated lateral lakes of the main stem Coeur d'Alene River (CSM Units 3 and 4) and a reference area located 140 km north of the contaminated area on the Kootenai National Wildlife Refuge and McArthur Wildlife Management Area. A preliminary study in 1986 involved the capture of incubating hens from nest boxes along the Coeur d'Alene River. These hens were weighed and bled to determine Pb concentrations and physiological characteristics. In 1987, Coeur d'Alene River nest boxes were monitored for nesting success information and birds were trapped for blood collection. Wood ducks that were found dead, as well as hens collected from nest boxes and euthanized were necropsied, and kidneys, liver and gastrointestinal (GI) tracts were collected. Birds were shot and collected at the reference area for comparison. Lead concentrations were measured in liver, blood, and GI tract contents, and Cd was measured in kidney and GI tract contents. From blood samples, hematocrit readings were taken, and hemoglobin concentration and δ-aminolevulinic acid dehydratase (ALAD) activity were determined.

Wood ducks nesting along the Coeur d'Alene River had an overall unadjusted nesting success rate of 55 percent (35 percent for Mayfield adjusted). Nesting success was directly related to clutch size with single clutches (4-15 eggs) having a 40 percent unadjusted success rate (20 percent Mayfield) and dump clutches (16-30 eggs) having a 71 percent unadjusted success rate (7 percent Mayfield). Dump nests had significantly greater daily survival rates than nests with 4-15 eggs, and had a 52 percent hatch rate compared to only 35 percent in clutches with 4-15 eggs. Livers from ducks found dead or trapped at Coeur d'Alene River contained elevated concentrations of Pb (up to 14.4 μg/g) compared to reference ducks, which had no detectable concentrations of Pb. Lead concentrations in GI tract contents from reference ducks (0.18-0.64 μg/g, $x = 0.32$) were much lower than those measured in GI tract contents from Coeur d'Alene River ducks (0.9-610 μg/g, $x = 34.7$). No shotgun pellets were found in the gizzards of any ducks collected. Blood Pb and ALAD activity were significantly different in wood ducks collected from the Coeur d'Alene River compared to reference ducks.

In both 1986 and 1987, wood ducks from the contaminated area had significantly different blood levels of ALAD and lead than those from the reference site (98-282 units, 0.2 μg/g). ALAD levels in June of 1986 ranged from 3-56 units for females while lead ranged from non-detect to 7 μg/g in females. In April and May of 1987, ALAD levels ranged from 0-63 units for females and

0-237 units for males while lead concentrations ranged from 0.2-8 µg/g for females and 0.1-5 µg/g in males. Except for hematocrit, several other physiological characteristics differed. Incubating female wood ducks captured later in the season at the contaminated area had lower mean body mass, hemoglobin and hematocrit levels and higher protoporphyin levels than males and females caught earlier in the season. No significant differences in lead concentrations or other physiological characteristics was exhibited in incubating hens in 1986 or 1987. Regression analysis revealed no significant relationship between lead concentration and time in the blood of incubating hens. Twenty-eight birds were recaptured and failed to demonstrate a temporal increase in blood levels. Though blood levels were elevated in almost all of the wood ducks sampled in the contaminated area, no link could be made between lead levels and reproductive success. Sacrificed hens had over 50 percent of their eggs hatch in an incubator. Examination of wood ducks with high lead levels revealed no obvious symptoms of lead poisoning. Statistically significant inverse relationships existed between blood lead and ALAD, hemoglobin, and body mass and a positive relationship with protoporphyrin. ALAD was significantly correlated with lead and protoporphyrin while hemoglobin was correlated with all variables except ALAD. Mean cadmium levels in kidneys of wood ducks was 0.13 µg/g in the reference area and 1.1 µg/g for males in the contaminated area. Incubating females in the contaminated area had mean levels of 7.5 µg/g while females killed in traps had a mean level of 5.6 µg/g.

The effect level of lead in blood is >0.5 µg/g. Out of 114 wood ducks captured, 87 surpassed this level in the contaminated area whereas only one duck out of twelve in the reference area did. The sensitivity of wood ducks to lead has yet to be determined. It has been noted that wood ducks have a shift in diet during incubation, as do the young wood ducks. This correlation with lead level is unknown but may increase the ingestion of high lead vegetation. The correlation of blood lead with body mass seemed due to the lower body mass associated with incubation. No explanation has been determined for the greater success rate of dump nests in this study. The cadmium levels in kidneys of wood ducks were not of concern since they were well below the no-effect level of >50 µg/g.

Blus et al. 1995

In order to determine the accumulation of lead and cadmium in waterfowl in the Coeur d'Alene River basin, blood and tissue samples were collected from both dead and living specimen. The study area included the upland areas near the smelter, the South Fork Coeur d'Alene River (CSM Unit 2) and the main stem Coeur d'Alene River from Wallace to Lake Coeur d'Alene, lateral lakes and riparian areas along the river and much of Lake Coeur d'Alene north of the mouth of the river (CSM Unit 3 and 4). Reference areas were the southern part of Lake Coeur d'Alene, the St. Joe River and upland areas away from the smelter. Dead birds were frozen for necropsy and blood samples were taken from live birds.

Lead was detected in most of the blood, liver and ingesta of waterfowl, with concentrations in livers of mallards ranging between 0.42 and 2.9 µg/g (wet weight). Lead concentrations in ingesta of two mallards were high. Mean blood lead concentrations in adults were significantly higher than those in juvenile mallards. ALAD activity was significantly inversely correlated with blood Pb levels, and was 87-95 percent lower than values for controls in experimental studies. Protoporphyrin values were positively correlated with blood Pb concentrations in adult mallards, but not in juveniles, and hemoglobin and hematocrit values were not correlated with blood Pb concentrations. Additionally, adult mallards had significantly lower levels of protoporphyrin, hemoglobin and hematocrit, and significantly higher levels of ALAD than juvenile mallards. Four Canada geese and one goldeneye found dead had lead levels of 8 to 38 μg/g in their livers. These concentrations exceed the lower lethal limit (5 μg/g) determined from experiments on birds. Two Canada geese contained lead shot in their gizzards but no other waterfowl was detected with lead shot. All five waterfowl found dead showed definite signs of lead poisoning. Cadmium was detected in mallard (0.95-7.5 μg/g) and goose (2.1-5.9 μg/g) kidneys from birds collected at contaminated sites, but all levels were below known harmful levels.

The authors indicated that birds feeding in aquatic environments are likely to ingest the highest levels of lead whereas those feeding on vertebrates would be the least exposed. Therefore, they note that a majority of lead exposure is from ingestion of sediment and biota containing lead from mining and smelting activities.

Beyer et al. 1997

In order to determine the role of sediment ingestion in lead exposure, 19 wood ducks were collected from along the Coeur d'Alene River and its lateral lakes, downstream of the Bunker Hill Superfund site (Beyer et al. 1997). Twenty-three wood ducks were collected from the St Maries and St. Joe Rivers (reference site), located ~75 km from the Superfund site. The acid-insoluble ash content of the digesta was collected and measured, and the values were used to estimate the sediment content of the diet. Additionally, the concentrations (ppm, dry weight) of Al, Cd, Cu, Fe, Mn, Pb, Sr, Ti, V and Zn were measured in the digesta.

Ducks from contaminated and reference sites ingested sediments at approximately the same low rate (less than 2 percent of the dry weight of the wood duck diet). When compared with values from the reference sites, the concentrations of Sr, Fe, Mn, Zn, Pb, and Cd in the digesta from the Coeur d'Alene River were elevated, while the concentrations of Al, Ti, Cu, and V were not elevated. Al and Pb were significantly correlated with each other and with six other elements and acid-insoluble ash, but neither one was correlated with Mn or Sr. All digesta samples from the reference site had low concentrations of Pb (< 10 ppm), except one sample with 130 ppm. Furthermore, 19 of the 23 samples of digesta from the reference sites had Pb concentrations below the detectable limit of 4 ppm. In contrast, only eight out of 19 samples from Coeur d'Alene contained less than 10 ppm of Pb and all of these samples had Al concentrations of 500 ppm or less, well below the mean of ~2000 ppm. The Al concentrations in the digesta are assumed to increase with the sediment content which implies that ducks not ingesting sediment had less exposure to Pb, even though the site was highly contaminated with Pb. Assuming 60 percent of the food was digested before the digesta was removed from the intestines, the mean of 32 ppm of Pb for the Coeur d'Alene River digesta samples corresponds to 13 ppm of Pb in the diet (dry weight). The maximum detected concentration of 120 ppm of Pb in the digesta corresponds to 48 ppm of Pb in the diet.

Although the Pb concentrations in samples of the digesta from the Coeur d'Alene River birds were low compared to the dietary concentrations known to kill mallards under controlled conditions, they were approximately four times those from the reference site. An interesting result of this study was that even though wood ducks ingested less than 2 percent sediment in their diets, the sediment was the main source of Pb to the wood ducks. The authors concluded that sediment ingestion should be considered an important means of exposure to Pb and other environmental contaminants that are relatively toxic but not readily taken up by plants or invertebrates.

Beyer et al. 1998

Feces from tundra swans, Canada geese, and mallards were collected from 1994 to 1996 from 19 sites within the Coeur d'Alene River basin and nine wetland sites from two reference areas located at the St. Joe and the McArthur Wildlife Management Area (Beyer et al. 1998). The objective of the study was to estimate exposure of the waterfowl to lead from mining activities and relate that exposure to the ingestion of contaminated sediments. Tundra swan fecal samples were collected in November from birds migrating south or overwintering, and in February through April from birds migrating north. Canada goose and mallard samples collected throughout the year included samples from both migratory and resident birds. Additional samples from ducks collected in August 1994 were not positively identified as mallard and were designated as unidentified duck.

Fecal samples were collected and analyzed for lead content and acid-insoluble ash content. Plants thought to be waterfowl food items were also collected and analyzed for acid-insoluble ash to approximate the acid-insoluble ash content of waterfowl diets (2 percent). The approximate acid-insoluble ash content for the waterfowl diets was based on the average acid-insoluble ash content value of 1.8 percent for four plant species: *Equisetum* (L.) (top 10 cm), cattail, *Typha* (L.) (tuber and stalk), pasture grass (blades), and Sagittaria (L.) (tubers).

Mean acid-soluble ash contents of 18 percent for Canada goose and tundra swan feces and 12 percent for duck feces indicate that waterfowl ingest substantial amounts of sediment in the Coeur d'Alene River basin. For tundra swans, seasonal differences in sediment ingestion are evident (average insoluble ash = 6 percent in November and 19 percent in February, March, and April) while seasonal differences in Canada geese ingestion are relatively minor (average insoluble ash = 18, 18, 21, and 15 percent for spring, summer, fall, and winter, respectively).

Median lead concentrations in feces of waterfowl from the reference sites were less than 5.0 mg kg^{-1}. The average value of lead in waterfowl feces from the Coeur d'Alene River basin was greater than those from the reference sites by a factor of 11, 27, 420, and 736 for mallard, Canada goose, Tundra swan, and unidentified duck, respectively. Average fecal lead concentrations were especially high, more than 1000 mg kg^{-1}, in tundra swan feces from Killarney Lake, Moffit Slough, and Harrison Slough, and in Canada goose feces from Harrison Marsh and Killarney Lake.

The authors found that lead concentration of the feces was closely related to the average lead concentrations in the sediment for each site. Regression equations were developed using this relation to predict waterfowl fecal lead concentrations from sediment lead concentrations in the Coeur d'Alene River basin. Of the three species of waterfowl examined in this study, tundra swans appear to have the greatest exposure to lead in the Coeur d'Alene River basin, followed by Canada geese and mallard ducks.

Blus et al. 1999

Blus et al. (1999) studied the persistence of high lead concentrations and the associated effects in tundra swans. Swans were collected during the spring migration in the Coeur d'Alene River system and in reference areas at Malheur National Wildlife Refuge and Lower Klamath National Wildlife Refuge. Blood samples were collected and analyzed for δ-aminolevulinic acid dehydratase (ALAD) activity, hematocrit levels, lead concentration, and hemoglobin content. Sick swans were captured by hand, euthanized, necropsied, and blood and liver samples collected for lead analysis. Swans captured in swim-in traps in contaminated areas were compared with moribund swans caught by hand in the contaminated area in 1987 and 1994-1995, and with reference swans.

Blood lead concentrations were significantly higher in swans from contaminated (0.82 μg/g in 1987 and 1.8 μg/g in 1995) areas compared to reference areas (0.11 μg/g). Although not significant, blood lead levels were higher in sick birds (3.3 μg/g in 1987 and 1995) compared to trapped birds within the contaminated areas. All geometric means for ALAD activity in the contaminated area (maximum of 75.7 units) were significantly less than the reference mean (175 units, excluding 2 outliers). Hemoglobin and hematocrits were significantly lower in sick swans compared to swans trapped in both contaminated and reference areas. Blood lead concentrations were significantly correlated with ALAD, hemoglobin and hematocrit. Nineteen swans were found sick in the contaminated area in 1987 and 1994-1995. Of these, 18 had signs of lead poisoning upon necropsy (the 19^{th} had aspergillosis), and liver lead concentrations (6.4 – 40 μg/g) were within the lethal range for waterfowl. Only 1 of the 18 contained ingested lead shot in the gizzard. Lead concentrations in livers of sick swans collected in 1994-1995 did not differ from those collected in 1987. The authors concluded that effects of lead on tundra swans had not diminished from 1987 to 1995.

Blus et al. 199? (persistent Pb in wood ducks)

In a study by Blus et al performed in 1992 and 1995 blood samples were collected from wood ducks in the main stem of the Coeur d'Alene River in order to determine blood lead persistence and associated effects as a follow up to a study completed in the sample area in 1986-87 (Blus et al 1993). Reference areas for this study included St. Joe and St. Maries Rivers as well as the extreme southern portion of Lake Coeur d'Alene. Migrating wood ducks were captured using walk-in traps baited with grain and using nest boxes to trap hens. Blood samples were taken and analyzed within 8 hours. All blood samples were analyzed for ALAD, hematocrit, and hemoglobin. ANOVA was used to determine significance between samples and Tukey's HSD test was used to separate means from ANOVA.

Blood lead concentrations in the contaminated area were significantly different than those in the reference area (152 of 189 samples greater than 0.25 μg/g, wet weight, compared to only 2 of 34 samples greater than 0.25 μg/g at the reference area). The mean lead concentration in 1995 was significantly higher (2.04 μg/g) than that of 1986-1987 (1.23 μg/g). ALAD was significantly different between the reference and contaminated areas though the mean in 1995 was significantly lower than the mean in 1992. The low means for ALAD (85 to 95 percent inhibition) in the contaminated area suggest the occurrence of high lead. Both hematocrit and hemoglobin were significantly different between reference and contaminated areas. Like that of ALAD the means of hematocrit (43.2 percent) and hemoglobin (13.9 g/dl) in 1995 were significantly lower than those in 1986-87 (48.4 percent, 16.3 g/dl) or 1992 (47.5 percent, 16.1 g/dl). Blood lead concentrations were inversely correlated with ALAD, hemoglobin and hematocrit. These values include adults only and exclude recaptures and non-detectable lead values.

Since data collected in 1992 exhibited low blood lead levels when the authors compared it to the 1986-87 data, but similar ALAD, hemoglobin and protoporphyrin levels, it is believed that there was an error in the blood lead analysis in 1992. Further evidence of this theory was exhibited when a significant difference existed between the means for ALAD, hematocrit, hemoglobin and lead concentrations for 1992 and 1995 data. A regression analysis was performed on the detectable values of lead in blood of 22 wood ducks from 1992 and indicated that the relationship of lead to ALAD was not significant. This result is questionable considering that in both 1986-87 and 1995 ALAD and blood lead levels have had significant relationships. Several other studies in the area also support the significance of the ALAD and blood lead level concentration relationship. Overall, accumulation of high levels of lead continues to put the wood ducks in danger of developing lead toxicosis.

Henny et al. 2000

In order to assess the effects of lead on Canada Geese and Mallards in the Coeur d'Alene River basin, Idaho, birds were collected and blood and livers were analyzed. McArthur Wildlife Management Area in Northern Idaho, Snake River site near Lewiston, Idaho, and Round Lake near the St. Joe River served as reference areas for Canada Geese while McArthur Wildlife Management Area, Round Lake and Turnbull National Wildlife Refuge in nearby eastern Washington served as reference sites for mallards. Canada geese were captured using drive traps or by dip nets whereas mallards were captured by walk-in/swim-in funnel traps, shot with a shotgun or caught by hovercraft. Birds were collected both alive and dead. Lead residue and hematological parameters were measured and compared among contaminated and reference areas. Blood samples were analyzed for ALAD, protoporphyrin, hematocrit, and hemoglobin. Live birds were bled and others were collected and euthanized to evaluate lead effects in the kidney, liver and blood, as well as to determine associated histopathology. Euthanized geese were analyzed for lead in the gizzards and lower gastrointestinal tracts. Results of this study were compared with a study published in 1995 (Blus et al 1995) which evaluated the same criteria.

Mean blood lead concentrations (wet weight) from the combined gosling and adult Canada geese in the Coeur d'Alene River basin (0.28 and 0.41 µg/g, respectively) were significantly greater than those found in goslings and adults from the reference areas (0.01 and 0.02 µg/g, respectively). However lead concentrations were not significantly different between adults and combined goslings in reference areas though adults had significantly higher lead concentrations. ALAD inhibition in the Coeur d'Alene River basin was apparent in both adults and goslings, and greater inhibition of ALAD was found in larger goslings than in smaller ones. All adults and goslings, except one, had greater than 50 percent ALAD inhibition. Significant differences in protoporphyrin were found between size classes of goslings in the reference areas; therefore comparisons of the Coeur d'Alene River basin and reference sites were made between size classes. The two smaller size classes had significantly higher levels of protoporphyrin in the Coeur d'Alene River basin than in the reference area while both the larger gosling classes and adults showed no statistically significant difference. Two larger classes of goslings showed a significant difference between the reference area and the Coeur d'Alene River basin when hematocrit levels were compared. Adults and smaller goslings showed no significant difference between the two areas. The two larger gosling classes from the Coeur d'Alene River basin has significantly reduced hemoglobin counts while adults showed no significant difference between reference and contaminated sites. When analyzing euthanized goslings, 9 of 10 showed background concentrations of lead in their livers while the other gosling liver met subclinical lead poisoning criteria. Strong linear relationships were found between liver and blood lead concentrations as well as kidney and blood lead concentrations.

Blood lead concentrations in adult and hatch year (HY) mallards from the Coeur d'Alene River basin (1.77 and 0.98 μg/g, respectively) were significantly higher than those from the reference sites (0.03 and 0.02 μg/g, respectively). Compared to data obtained in 1987, HY mallards contained significantly higher concentrations of lead in 1994-95. ALAD in the reference area was significantly different between sizes of HY mallards. In both size classes in Coeur d'Alene River basin, ALAD was significantly inhibited and 94 percent showed 50 percent or greater inhibition. In adults all showed inhibition of greater than 50 percent. Protoporphyrin values in both adults and HY mallards were significantly different between the reference area and the contaminated areas. No significant differences were found for hematocrit or hemoglobin levels between reference and Coeur d'Alene River basin sites. Mallards in the Coeur d'Alene River basin, both bled and euthanized, had a mean blood lead concentration of 1.77 μg/g. It was found that 17 of the 22 euthanized mallards had liver lead concentrations of >2 μg/g. This indicates significant environmental exposure, and possibly subclinical or clinical lead poisoning.

Since blood lead concentrations for the euthanized birds were not significantly different from concentrations in bled birds, additional info from euthanized birds was considered representative of the two populations as a whole. When compared with laboratory studies, the Coeur d'Alene River goslings contained less lead than those exposed to 12 percent lead in sediment in the lab. Yet hematocrit and hemoglobin reduction in the field was more severe than in the lowest lab treatment. Protoporphyrin increase in the field was greater than in lab experiments with a 12 percent lead sediment exposure in both HY and adult mallards. Findings suggest that more severe protoporphyrin effects in the field with a lower lead concentration may be a result of a less optimum diet in the field. The authors noted that in laboratory studies mallards fed the same percentage sediment in the diet as Canada geese have a higher resulting blood lead concentration.

The authors concluded that HY and adult breeding mallards in the Coeur d'Alene River basin accumulated enough lead to adversely effect a series of blood biomarkers that respond to lead and several were considered lead poisoned. There has been no decrease in blood lead concentrations in adult mallards between 1987 and 1995. Furthermore, since few of the Canada geese or mallards contained ingested lead shot, the authors suggested that the main source of exposure was from lead contaminated sediment associated with upstream mining.

3.2.1.3.7 Raptors

Three site-specific field studies of raptors including osprey, American kestrels, northern harriers, red-tailed hawks, great horned owls, western screech owls, and bald eagles have been conducted in the Coeur d'Alene River basin. Summaries of these studies follow.

Henny et at 1991

Blood samples were collected from osprey in the Coeur d'Alene River basin to assess the blood lead concentrations as a result of mining and smelting practices near Kellogg, Idaho (Henny et al. 1991). Osprey nest sites were visited along the Coeur d'Alene River from 2 km above Cataldo Mission to the river's mouth at Harrison, Idaho. Fish samples were taken at Thompson Lake, a lateral lake of the Coeur d'Alene River, Cougar Bay at the north end of Lake Coeur d'Alene and Lake Pend Oreille. Coeur d'Alene Lake and the St. Joe River were considered intermediate areas while Lake Pend Oreille and Flathead Lake in Montana were considered reference areas since they are both 100 to 175 miles from the study area. Blood samples were extracted from the birds and analyzed within 4 hours. Fish were frozen for later analysis.

Blood lead concentrations in adult and nestling osprey trapped along the Coeur d'Alene River were significantly higher than those trapped at Coeur d'Alene Lake or Pend Oreille and Flathead Lakes. This occurrence was significantly more pronounced in 1987 when the study used a larger sample population. ALAD was significantly inhibited in the Coeur d'Alene River population for both adults and nestlings. The authors associate this inhibition with recent lead exposure. Protoporphyrin values in adults were significantly elevated on the Coeur d'Alene River in 1987 and in nestlings when the two years were combined. Hemoglobin and hematocrit concentrations showed no significant relationship to lead concentration. Weight of nestlings was monitored and no significant difference was found between areas. Lead concentrations in fish were highest in the bottom feeding brown bullhead and decreased from the Coeur d'Alene River to Coeur d'Alene Lake to Lake Pend Oreille. While lead concentrations may have been high, osprey exposure via this route is minimized since they don't eat large fish bones, a site of lead storage, and regurgitation habits. No significant differences were found in nesting success between years at any location. Nor was there any correlation between lead concentrations in adult females and clutch size.

Henny et al. 1994

Blood samples were taken from American kestrels, northern harriers, red-tailed hawks, great horned owls, and western screech owls along the Coeur d'Alene River floodplain and nearby uplands from Kellogg to the mouth at Harrison, Idaho in order to assess lead exposure resulting from mining and smelting practices at Kellogg-Smelterville, Idaho (Henny et al. 1994). Other factors that were studied included residue concentrations in livers and kidneys of raptors, lead and cadmium in prey species of raptors and the influence of contaminants on raptor nesting success.

Nest boxes were placed along the Coeur d'Alene River floodplain and nearby uplands to attract nesting American kestrels. Adults were bled at the egg stage while nestlings were bled just before fledging. Great horned owl, red-tailed hawk, and northern harrier nests were found by searching appropriate habitat while western screech owls nested in boxes placed in the area for American kestrels and wood ducks. Reference blood samples were collected for all birds from upland areas away from the Coeur d'Alene River basin. Non-parametric JT and Fisher's Exact tests were used to test for differences between years within locations.

Blood lead concentrations were higher along the Coeur d'Alene River than in the reference area for nestling northern harriers and adult and nestling American kestrels, but the difference was only significant for nestling American kestrels. Cadmium concentrations found in blood were not significant. Adult American kestrels showed a significant inhibition of ALAD activity along the Coeur d'Alene River, but no significant relationship between ALAD and blood lead level. Protoporphyrin values in nestling and adult American kestrels showed no significant difference between the Coeur d'Alene River and reference area. Hematocrit values were not significantly different between the Coeur d'Alene River and the reference area for northern harrier nestlings and adult American kestrels. Nestling American kestrels of the Coeur d'Alene River did however show significantly reduced hematocrit levels. Hemoglobin was significantly lower in nestling and adult American kestrels in the Coeur d'Alene River but not for northern harriers. Analysis of American kestrel and northern harrier nestling livers revealed a correlation between concentration of lead in blood and concentration in liver. Red-tailed hawk and great horned owl data was limited, but suggested the same correlation. Mice and voles were collected in the Coeur d'Alene River basin, as they are common prey species for raptors. Lead concentrations were found to accumulate in the bone of these rodents. Because most raptors do not eat large bones, which are regurgitated or excreted in cast pellets, their exposure via ingestion is minimized. No significant differences were found in productivity between years at each location for American kestrels. Nor was any significant relationship found between lead blood concentration in females and clutch size.

Audet et al. 1999

Bald eaglet blood samples, prey remains, and regurgitated pellets as well as brown bullheads and dead eagles in the Coeur d'Alene River basin area were collected and analyzed in order to determine the sources of lead in eagles and the mechanisms by which they are poisoned (Audet et al. 1999). Blood samples were collected from eaglets at two nests located in Mission Slough and Swan Lake, both located in the contaminated area and from eaglets at one reference nest about 92 km north of the Coeur d'Alene River basin. Blood samples were analyzed within 8 hours of collection. Eaglet blood samples were analyzed for lead concentration, hemoglobin and ALAD, as well as for protoporyphyrin and hematocrit. Prey remains and regurgitated pellets from and surrounding the nest area were collected in order to identify food items eaten by the eagles. Samples were separated into four classes (fishes, birds, mammals, and unknown). Brown bullhead samples were collected from three areas in the Coeur d'Alene River basin and three areas in the adjacent St. Joe River basin. Samples were then analyzed for lead. Dead eagles were collected by the U.S. Fish and Wildlife Service. These birds were x-rayed and examined for gross pathological lesions and their livers were analyzed for lead. Limited statistical analysis was completed on blood data due to small sample size. The assumption that data were uncorrelated was due to the unavailability of the covariance between birds in the reference and assessment areas. Statistical comparisons performed on lead concentrations in prey items were made using Wilcoxon's rank sum test. Distribution of lead levels in brown bullhead was compared between sites using the Kruskal-Wallis test.

Blood lead concentrations in the Coeur d'Alene River basin (0.03 – 0.18 µg/g, wet wt.) were higher than those measured in eaglets in the reference area (0.02-0.03 µg/g). Hematocrits were slightly lower at the reference site (32 percent compared to 33.25 and 35 percent in Coeur d'Alene River basin eaglets). Protoporphyrin values were highly variable between nests and sites, while hemoglobin values were similar between sites. ALAD inhibition in the assessment area ranged from 35 percent to 65 percent of the reference area ALAD activity. Of the 41 prey remains and identified remains in castings near nests, 27 contained bird remains, 13 contained fish, and 11 contained mammals. The mean lead concentrations for Coeur d'Alene River basin bullheads (3.81 – 122.21 ppm, wet wt.) were significantly higher than for St. Joe River basin bullheads (non-detectable-2.86 ppm). Lead concentrations increased as one moved downstream along the Coeur d'Alene River basin. Finally, 6 of 10 dead bald eagles collected from 1993 to 1998 died from lead poisoning and had liver Pb concentrations of 19.2-77.4 ppm. None of these contained ingested lead artifacts.

Lead exposure to the eaglets was conclusive. Elevated lead concentrations in brown bullhead suggest that this exposure occurred via ingested food. Mean blood lead concentrations were higher in the Coeur d'Alene River basin than in the reference area. When compared with studies done by Henny and others (1991 and 1994), eaglets had similar blood lead concentrations when compared to eaglets in 1986-87 and though their levels are well below American kestrel nestlings they are well above all other nestlings surveyed in Henny et al. (1994).

The authors list four possible types of lead exposure including lead shot embedded in tissue of waterfowl, lead sinkers through ingestion of fish, lead offal and ingestion of lead associated with Coeur d'Alene River basin sediments or prey items. They also note that the leaded sediment and prey pathway poses a year round risk to bald eagles unlike the other types.

3.2.1.3.8 Passerines

Two site-specific field studies on passerine species (American robins, tree swallows, and song sparrows) in the Coeur d'Alene River basin were reviewed and summarized below.

Johnson et al. 1990

The effects of lead exposure to songbirds in the Coeur d'Alene River basin were studied (Johnson et al. 1997), and later published (Johnson et al 1999), by Johnson and others. Livers and blood from song sparrows and American robins were collected and analyzed. Seven sites were sampled including Blessing Slough, Moffit Slough, Campbell Marsh, Bare Marsh, Strobl Marsh, Lane Marsh and Rose Lake. St. Joe and North Fork Coeur d'Alene River basins served as reference areas and sites sampled within that area included Round Lake, Chatcolet Lake and Little North Fork Coeur d'Alene River. Mist nets were used to catch the passerines. Blood samples were stored on ice and analyzed within 7 hours. Blood samples were analyzed for hematocrit and ALAD, both blood biomarkers of lead exposure. ANOVA was used in assessing sex, location or interaction effects

Mean ALAD values for the American robin and the song sparrow were 75 and 51 percent inhibited, respectively in the assessment area compared to reference areas. This inhibition was statistically significant. Hematocrit values differed significantly between sexes for the American robin but not for the song sparrow. There was no significant relationship between differences in hematocrit levels at assessment areas compared to reference areas for either the American robin or the song sparrow. Lead concentrations found in livers of song sparrows in the assessment area (1.93 ppm, wet weight) were significantly greater than those from the reference sites (0.1 ppm).

The authors concluded that a large number of American Robins and song sparrows are being exposed to potentially harmful levels of lead.

Blus et al. 1995

In order to determine the accumulation of lead and cadmium in passerines in the Coeur d'Alene River basin, blood and tissue samples were collected from both dead and living passerines. The study area included the upland areas near the smelter, the South Fork Coeur d'Alene River, and the main stem Coeur d'Alene River from Wallace to Lake Coeur d'Alene including the lateral lakes and riparian areas along the river and much of Lake Coeur d'Alene north of the mouth of the river. Reference areas were the southern part of Lake Coeur d'Alene, the St. Joe River and upland areas away from the smelter. Dead birds were frozen for necropsy and blood samples were taken from live birds.

Blood lead concentrations in the American robin were high (0.27-0.87 µg/g, wet weight) and slightly elevated in tree swallows (non-detectable- 0.75 µg/g) from contaminated areas. In comparison, reference robins and tree swallows had blood lead concentrations of 0.31 and 0.2-0.41 µg/g, respectively. Some nestling robins had accumulated potentially hazardous levels of lead in blood and tissues. Detected levels of cadmium (0.11-1.1 µg/g in all passerines collected) were of little concern since they were below known harmful concentrations.

The authors concluded that birds feeding in aquatic environments are likely to ingest the highest levels of lead whereas those feeding on vertebrates would be the least exposed. A majority of lead exposure is noted to have come from ingestion of sediment and biota containing lead from mining and smelting activities.

3.2.1.3.9 Mammals

Three site-specific field surveys of mammals including mink, muskrats, deer mice, voles, and horses in the Coeur d'Alene River basin were conducted. Summaries of these studies are summarized below.

Burrows et al. 1981

Blood samples were taken from horses living in the Coeur d'Alene River valley area in order to assess the lead concentrations due to mining practices and resulting contamination (Burrows et al. 1981). The sampling area was in the Coeur d'Alene River Valley from 1 to 30 km east and west of the smelter. Blood samples were collected from 125 horses and ponies in this area in 1972. Horses from other Pacific Northwest areas were utilized as controls to establish background levels.

Blood lead concentrations of 0.35 ppm or more occurred in 11 of the 118 usable samples. All 11 horses were either being fed local hay or had some access to local pasture forages, and most were found 9 to 15 km west of the smelter between Pinehurst and Cataldo. One horse with a blood Pb level of 0.7 ppm was treated in 1971 for lead intoxication. Control horses mean blood Pb concentration was 0.17 ppm. There was no apparent correlation between distance from the smelter and blood Pb concentration. Clinical problems reported in horses near the smelting area included anemia, lack of coordination, short windedness, severe respiratory difficulties on exercise, regurgitation of food and water from the nostrils and death. The blood Pb concentrations and clinical observations indicate that lead is a significant health hazard for horses in this region.

Blus et al. 1987

In order to assess the adverse effects of mine contamination in the Coeur d'Alene River basin, mammalian specimen from Washington and Idaho were collected and analyzed for metal contaminants including Cu, Hg, Pb, Zn and Cd (Blus et al. 1987). Animals were collected from several different sites with varying contamination levels including the North Fork Coeur d'Alene River and the main stem of the Coeur d'Alene River, as well as an uncontaminated site in Okanogan County, Washington. Many specimen from the main stem site were directly collected from the Thompson Lake area, 70 km downstream from the center of mining and smelting activities near Kellogg. Other collection regions within the main stem included the Bunker Hill Smelter complex in Kellogg. All livers were analyzed for Cu, Hg, Pb and Zn. Kidneys were analyzed for Cd only, while stomach contents of mink and muskrats, as well as whole bodies and embryos of deer mice and voles (*Microtus spp.*) were analyzed for Cd, Cu, Hg, Pb and Zn. Comparisons were made among the three sites sampled and among species.

Mink livers from the main stem of the Coeur d'Alene River contained significantly higher mean Pb levels than the other two collection sites. The maximum concentration of Pb from the other two areas was 3.2 μg/g, while mink livers from the main stem had concentrations as high as 22.0 μg/g. Mean Hg concentrations were highest in mink livers from Washington. Muskrats from the Thompson Lake area had significantly lower concentrations of Pb, Cu and Hg in their livers (0.51, 1.4, and <0.22 μg/g, respectively) than the mink trapped in the same area (4.1, 7.9, 0.64 μg/g, respectively). Additionally, levels of Pb in livers of muskrats (0.27-0.96 μg/g) were relatively low compared with the amount of Pb in their stomach contents (1.6-14.0 μg/g). Whole body Pb concentrations in deer mice (23.5-173 μg/g) and voles (52.7-58.0 μg/g) trapped in a heavily contaminated area in Kellogg were elevated. In comparison, liver Pb concentrations (maximum of 10.5 μg/g for both species) were much lower. Zinc showed a similar trend with a maximum whole body concentration of 362 μg/g in mice and voles, compared to a maximum liver concentration of 62.7 μg/g. Concentrations of Cu were similar in whole body and liver while kidney concentrations of Cd were 10 times those in whole bodies. This likely due to the fact that Cd is primarily stored in soft tissues and not in bone. Finally, a limited trapping effort in a small roadside area in Kellogg indicated that population densities of voles and deer mice were high; however, some adult female voles had serious disease of the tail and feet and evidence of embryo resorbance.

Concentrations of Pb in livers of mink and deer mice exceeded 10 μg/g, a level that is of diagnostic significance in livers of experimental animals. However, liver levels of < 5 μg/g have been known to kill mammals with behavioral and physiological signs of lead intoxication. The authors concluded that lead levels in some mink and small mammals in northern Idaho were sufficiently elevated to induce adverse effects, and that declines in mammal populations have probably occurred due to the toxicity of metals and associated secondary effects on cover and food supply.

Blus and Henny 1990

Mink in Northern Idaho were collected and analyzed for lead and cadmium levels as a follow up to a previously published study (Blus et al. 1987). Mink were obtained from trappers during 1981-1982 and 1986-1987 in the Coeur d'Alene River system including Thompson Lake and other nearby lateral lakes adjoining the main stem of the Coeur d'Alene River 40 km downstream from the mining complex near Kellogg and the North Fork Coeur d'Alene River. Liver, kidneys, and stomach contents were collected and freeze-dried. Samples were analyzed for both lead and cadmium in stomach contents, cadmium in kidneys, and lead in livers. Comparisons of lead and cadmium levels were made between sampling years.

Lead was detected in all samples except three livers of mink from the North Fork Coeur d'Alene River in 1981-82. Mean lead concentrations from mink at the lateral lakes adjoining the main stem of the Coeur d'Alene River did not differ significantly between the 1981-82 samples and those from 1986-87 (4.1 and 3.2 μg/g, wet wt., respectively). However, both sample collections were significantly higher than eight samples from the North Fork Coeur d'Alene River in 1981-82 (0.27 μg/g). Lead concentrations in stomach content were positively correlated with lead concentrations in the liver, but the relationship was not significant. Cadmium was detected in all but three of the samples analyzed. In both stomach contents and kidneys cadmium levels were relatively low (nondetectable-0.46 and nondetectable-2.9 μg/g).

All measured cadmium concentrations were lower than those associated with lethal or sublethal effects in experimental mammals. In contrast, Pb concentrations found in 14 samples from the lateral lakes along the main stem of the Coeur d'Alene River were high enough to put mink at risk for lead toxicosis (≥ 5 μg/g in experimental animals). The persistence of high lead levels in mink from the main stem was related to high concentrations in sediment and biota. Though population trend data is unavailable, the authors suspect that mink along the heavily contaminated segment of the river and some lateral lakes are adversely effected.

why is background discussion here?

3.2.2 Physical and Biological Stressors-Response/Condition Analysis

Background values for soil and sediment were determined as the higher of the 90th percentile of the concentration data from Gott and Cathrall's (1980) extensive sampling of soil from the Coeur d'Alene River basin, or Le June and Cacela's (1999) 95th percentile of data from their "pooled reference areas" (Table 3.2.2-1). The same data are used for soil and sediment because the ultimate source of sediment in the Coeur d'Alene River basin is the soil and rock that the soil is derived from and because soil and sediment are interchanged between the floodplain and waterbodies during flood events. It is recognized that the processes of weathering, transport by erosion, dissolution, chemical precipitation, and accumulation of organic matter can alter the composition of sediment relative to upland soil and rock, but the general bulk chemistry (with regard to metals content) of sediment is likely to be similar to that of soil in the same watershed. For that reason the background values discussed in this section are assumed to apply to both soil and sediment. As with water, there appear to be geographic variations in background values of metals in soil and sediment (RI report, Section 6.2), but ~~for screening and risk~~ evaluation, the ~~values in Table~~ 3.2.2-2 ~~are used~~. Regional variations in background could be considered in selecting and evaluating remedial alternatives in the FS.

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3.2.2.1 Bank Stability

Levels of bank instability in montane stream systems that are beyond natural patterns of dynamic equilibrium pose risks to aquatic receptors through a number of mechanisms. The primary mechanism of risk exposure for fish from bank instability due to mining-related releases of hazardous waste is the loss of channel complexity associated with underbank habitats, and widening and shallowing of channels. Bank instability is part of a suite of interrelated physical factors that constitute risk, including increasing levels of substrate fines, bedload instability, loss of large woody debris (LWD) recruitment, and increasing stream temperatures. As with fish, the survival of amphibian receptors, many of which are dependent on a complex suite of habitats to complete their life cycle histories, may be limited by the habitat simplification that accompanies bank instability. Changes in the amount and distribution of various habitat types in the stream channel network will also impact populations of macroinvertebrate species dependent on specific habitat types, which can have community-level impacts.

These measures of ecosystem and receptor characteristics are synergistically related in causes and effects on receptors, and water and sediment chemistry can have direct toxic and behavioral effects on aquatic receptors at any given location.

Risk to identified aquatic receptors in riverine habitats in CSM Units 1 and 2 from bank instability is assessed qualitatively. The qualitative evaluation is based on RBP, SRI, and BURP ratings of bank instability, modified by the range of bank stability ratings for suitable reference streams.

Rosgen Type B reference channels have been identified as suitable reference areas for CSM Unit 1 segments. Bank stability ratings for Rosgen Type B reference streams in the Coeur d'Alene, St. Joe, and St. Regis River basins score at or above 85 percent, with the exception of one location on the St. Regis River scoring 75.5 percent. This corresponds to the general range seen in relatively undisturbed Rosgen Type B reference streams in undisturbed watersheds in the Salmon River basin, where 75 percent of surveyed reaches of the same channel type exceeded 83.3 percent bank stability with a median score of 100 percent (see Table F-3.1.1.2.2.1-2 in Appendix F) (Bauer and Ralph 1999).

Rosgen Type C reference channels have been identified as suitable reference areas for CSM Unit 2 segments and main stem areas of selected segments in CSM Unit 1 of moderate gradient with Type C stream channels (PineCrkSeg03, BvrCreekSeg01, and PrichCrkSeg03). Bank stability ratings for reference streams in the Coeur d'Alene, St. Joe, and St. Regis River basins score at or above 75 percent. This corresponds to the general range seen in relatively undisturbed streams in the Salmon River basin, where 75 percent of surveyed reaches of the same channel type scored above 65.1 percent bank stability with a median score of 89.4 percent (see Table F-3.1.1.2.2.1-2 in Appendix F) (Bauer and Ralph 1999).

The RBP scoring protocol, modified by scores for bank stability in reference streams for CSM Units 1 and 2, was used to define the risk criteria for the bank stability measure. Scores are defined as follows:

- No risk: The RBP scoring protocol identifies streambanks with 90 percent or greater stability as optimal. In general, the optimal range for bank stability conditions as defined by the RBP protocol is used to frame levels of risk to aquatic receptors. Optimal conditions correspond to no risks, sub-optimal conditions to low risks, marginal conditions to moderate risks, and poor conditions to high risks. However, estimated bank stability conditions in reference streams for CSM Units 1 and 2 score below optimal ranges in some cases (see Table F-3.1.1.2.2.1-2 in Appendix F), indicating that some downward modification of risk criteria is desirable to reflect the influence of non-mining-related stressors on bank stability. Therefore, the range of bank stability corresponding to no risk to aquatic receptors is defined as greater than 85 to 100 percent of reach length.

- Low Risk: Bank stability from greater than 75 to 85 percent of reach length.

- Moderate Risk: Bank stability from greater than 40 to 75 percent.

- High Risk: Bank stability 40 percent or less.

In some segments the bank stability estimates between survey locations vary considerably, indicating that bank stability conditions throughout the segment are similarly variable. In both the BURP and R2 habitat surveys, the survey locations were selected to be generally representative of habitat conditions for the stream system. Where data sets lead to conflicting interpretations, an average value for bank stability is assumed and a corresponding level of risk is assigned to the segment.

Bank stability data for MidGradSeg04 and CSM Unit 3 were evaluated for risk characterization purposes. The primary source of available information is the habitat conditions data collected in June of 1999 by T.A. Wesche on the main stem Coeur d'Alene River (Wesche 1999). Wesche inventoried areas with eroding streambanks on the main stem from Coeur d'Alene Lake to the confluence of North Fork and South Fork Coeur d'Alene River using foot and boat surveys. As discussed above, while these data provide an accurate accounting of bank instability, it was not possible to characterize risks in these CSM segments due to a lack of reference area data and literature values needed to develop a risk rating scale. Bank stability data collected by Wesche are summarized in Table F-3.1.1.2.2.1-3 in Appendix F).

3.2.2.2 Stream Substrate Composition and Mobility

The substrate composition and mobility measure is derived from several quantitative and qualitative characteristics, which together provide an indication of the channel substrate condition. These characteristics are described in Section 3.1.1.2.2.2. For a given CSM segment, a statement of risk to aquatic receptors from degraded substrate composition and mobility is made through a qualitative evaluation of scores for each characteristic.

Two categories of characteristics were considered in the risk evaluation: the stream channel substrate composition, as represented by the substrate percent fines, substrate embeddedness, and substrate distribution and percent stable characteristics; and the stability of channel substrate, as represented by the bottom scouring and deposition characteristics, and deposition of fines and brightness characteristics. (As noted in Section 3.1.1.2.2.2, the RBP and SRI protocols both have a bottom scouring and deposition characteristic.) The overall risk values for these categories are then interpreted using best professional judgment to arrive at an overall rating of risk in a given CSM segment.

When considering these data, it is important to recognize that they represent a limited time series and are snapshots of conditions based on recent flow history. Therefore, these data may not capture the full range of substrate composition and mobility characteristics that occur in the watershed over time, or the degree to which this range of conditions resembles or departs from reference conditions. Further, the characteristics and scaled conditions examined are indicators of intact versus degraded ecological conditions under many circumstances; however, there may be cases where a high rating for a given characteristic may occur in areas with poor conditions. For example, armored channels (substrate degraded down to cobble- and boulder-sized substrate) with simplified channel structure and high stream energy will generally have a low percentage of substrate fines and little or no evidence of bedload mobility. However, such channels will lack the habitat structure and diversity of substrate sizes (particularly gravel- to pebble-sized substrate less than 3 inches in diameter) necessary to support salmonid populations and a diverse macroinvertebrate community. Insufficient data are available on a segment-by-segment basis to determine the degree to which scores for a given characteristic may misrepresent habitat quality. The degree to which this issue affects risk estimation for this measure is addressed in the uncertainty analysis.

Rating scales were derived for each characteristic in the substrate composition and mobility measure from literature values and the scoring parameters used in the RBP and SRI protocols. The rating scales were then adjusted on the basis of scores for each characteristic observed in suitable reference streams. Rating scales for each characteristic are described below, including a discussion of caveats that contribute to uncertainty in the risk estimation.

3.2.2.2.1 Substrate Percent Fines, Substrate Embeddedness, and Substrate Distribution and Percent Stable

Risk thresholds for these three characteristics were defined using literature values for substrate fines (Hickman and Raleigh 1982; Spence et al. 1996) and the RBP and SRI protocol scoring ranges for substrate embeddedness and substrate size distribution and percent stable, modified by scores observed in suitable reference channels. Scores for these characteristics for Rosgen

Type B reference channels are shown in Table F-3.1.1.2.2.2-2 in Appendix F, and scores for Rosgen Type C reference channels are shown in Table F-3.1.1.2.2.2-3 in Appendix F. Risk thresholds are defined in the following discussion.

3.2.2.2.1.1 Optimal Conditions – No Risk to Aquatic Receptors

Literature values for substrate fines indicate that substrate fines levels of 5 percent or less are optimal. Substrate percent fines levels in two of the Rosgen Type B channels identified as possible reference streams for CSM Unit 1 Segments were higher than levels identified in literature as limiting to salmonid survival, suggesting that these streams do not provide optimal habitat conditions for comparison (see Appendix E). In reference streams, substrate fines levels average 8.8 percent, therefore levels from 0 to 9 percent were judged to constitute no risk to aquatic receptors in CSM Unit 1 segments. Using the RBP scoring protocol, embeddedness scores of 20 to 16, reflecting substrate embeddedness levels from 0 to 25 percent, are optimal. The average score for the substrate embeddedness characteristic in Rosgen Type B channels is 18.5, suggesting that the scoring range of 16 to 20 for this characteristic corresponds to no risk to aquatic receptors (see Appendix E). Scores for substrate composition and percent stable in Rosgen Type B reference channels average a score of 6. The range of scores corresponding to optimal conditions for this characteristic is 4 to 7 (substrate composition and stability "normal" along 80 to 100 percent of reach length). This range is defined to correspond to no risk to aquatic receptors.

For Rosgen Type C channels identified as possible reference areas for CSM Unit 2 segments, scores for substrate fines averaged 7.2 percent (Section 3.1.1.2.2.2). Therefore, the range of substrate fines judged to correspond to no risk to aquatic receptors in CSM Unit 2 is from 0 to 8 percent. Substrate embeddedness scores for reference channels averaged 17.7, suggesting that the RBP protocol range of 16 to 20 for this characteristic corresponds to no risk to aquatic receptors. Scores for substrate size distribution and percent stable averaged 8.0 (substrate size distribution and stability "normal" along 80 percent of reach length). This indicates that scores of 4 to 8 for this characteristic correspond to no risk to aquatic receptors.

3.2.2.2.1.2 Sub-Optimal Conditions – Low Risk to Aquatic Receptor

The no-risk thresholds defined above, literature values for substrate fines, and the RBP and SRI scoring protocols were used to define the range of scores corresponding to low risks to aquatic receptors for these characteristics. In CSM Unit 1 segments, substrate fines levels from 9 to 13 percent, substrate embeddedness scores from 15 to 11, and substrate distribution and percent stable scores of 8 to 11 each correspond to low risk to aquatic receptors. In CSM Unit 2 segments, substrate fines levels from 8 to 13 percent, substrate embeddedness scores from 15 to 11, and substrate size distribution and percent stable scores from 9 to 11 each correspond to low risks to aquatic receptors.

3.2.2.2.1.3 Marginal Conditions – Moderate Risk to Aquatic Receptors

Literature values for substrate fines and the RBP and SRI scoring protocols were used to define the range of scores corresponding to moderate risks to aquatic receptors in CSM Units 1 and 2. Substrate fines levels from greater than 13 to 20 percent, substrate embeddedness scores from 10 to 6, and substrate size distribution and percent stable scores from 12 to 15 each correspond to moderate risks to aquatic receptors.

3.2.2.2.1.4 Poor Conditions – High Risk to Aquatic Receptors

Literature values for substrate fines and the RBP and SRI scoring protocols were used to define the range of scores corresponding to high risks to aquatic receptors in CSM Units 1 and 2. Substrate fines levels greater than 20 percent, substrate embeddedness scores from 5 to 0, and substrate size distribution and percent stable scores of 16 each correspond to high risks to aquatic receptors (Appendix E).

3.2.2.2.1.5 Caveats to Consider When Interpreting Substrate Fines and Embeddedness Levels

In general, a low level of substrate fines in combination with a diversity of substrate sizes and a complex channel structure indicates desirable habitat conditions in montane stream systems. Straightened stream channels lacking large woody debris (LWD) recruitment and retention develop high stream energy during high flow conditions and may be scoured down to immobile boulder- and cobble-sized substrate. Such degraded and simplified stream channels may have very little or no substrate fines, but will provide poor conditions for salmonids and many macroinvertebrate species. Therefore, while high levels of substrate fines indicate degraded conditions in stream habitat that pose risks to aquatic receptors, a low level of substrate fines alone cannot be used to distinguish intact versus degraded habitat conditions.

Ideally, the substrate size distribution and percent stable characteristic should indicate these types of degraded channel conditions. Channels degraded down to an armoring of cobble- and boulder-sized substrate should present a sub-optimal score for this characteristic. Therefore, a high score of substrate fines in combination with a moderate or low score for substrate size distribution and percent stable may indicate a degraded channel and poor habitat conditions.

3.2.2.2.2 Bottom Scouring and Deposition, Scouring and Deposition, Deposition of Fines, and Brightness

Risk thresholds for these three characteristics were defined using the RBP and SRI scoring protocols, modified by conditions observed in reference channels. Scores for these characteristics for Rosgen Type B reference channels are shown in Table F-3.1.1.2.2.2-2 in Appendix F, and scores for Rosgen Type C reference channels are shown in Table F-3.1.1.2.2.2-4 in Appendix F. Risk thresholds are defined in the following discussion.

3.2.2.2.2.1 Optimal Conditions – No Risk to Aquatic Receptors

Scores in Rosgen Type B reference channels were within RBP and SRI optimal ranges for the bottom scouring and deposition (range 12 to 15), scouring and deposition (range 6 to 11), and deposition of fines (range 4 to 7) characteristics. Therefore the optimal ranges for these characteristics were defined to correspond to no risk to aquatic receptors in CSM Unit 1 segments (see Appendix E). Scores for the brightness characteristic averaged 1.5; therefore, this was defined as the threshold for risk to aquatic receptors for CSM Unit 1 segments.

In Rosgen Type C reference channels, average scores for bottom scouring and deposition as well as scouring and deposition were within RBP and SRI optimal ranges, so the optimal ranges for these characteristics were defined to correspond to no risks to aquatic receptors in CSM Unit 2 segments. Scores for deposition of fines averaged 7.2, within the coarsely defined range of scores for optimal conditions for this characteristic (4 to 7) when rounded down. Therefore, the optimal range for this characteristic was defined to correspond to no risk to aquatic receptors in CSM Unit 2 segments. As with CSM Unit 1, scores for brightness in Rosgen Type C reference channels averaged 1.5; therefore, this level was defined as the no-risk threshold in CSM Unit 2 segments.

3.2.2.2.2.2 Sub-Optimal Conditions – Low Risk to Aquatic Receptors

RBP and SRI scoring ranges for suboptimal conditions and the no-risk thresholds defined above were used to define the low-risk thresholds for these characteristics. For CSM Unit 1 and Unit 2 segments, the unmodified suboptimal scoring ranges for bottom scouring and deposition (range 8 to 11), scouring and deposition (range 12 to 17), and deposition of fines (range 8 to 11) were defined to correspond to low risks to aquatic receptors (Appendix E). A range of greater than 1.5 to 2 for the brightness characteristic was defined to correspond to low risks.

3.2.2.2.2.3 Marginal Conditions – Moderate Risks to Aquatic Receptors

RBP and SRI scoring ranges for marginal conditions were defined to correspond to moderate risks for aquatic receptors in CSM Unit 1 and 2 segments (Appendix E).

3.2.2.2.2.4 Poor Conditions – High Risks to Aquatic Receptors

RBP and SRI scoring ranges for poor conditions are defined to correspond to high risks for aquatic receptors in CSM Unit 1 and 2 segments (Appendix E).

Scores for the two categories of substrate composition mobility characteristics corresponding to risk thresholds as defined above are summarized in Table 3.2.2.2-1. For the purpose of risk estimation in a given CSM segment, scores for each of these habitat characteristics were interpreted as a whole to arrive at a qualitative risk statement based on best professional judgment. The scores for substrate composition and mobility characteristics, along with interpretation of ecological risk for segments with available data, are presented by CSM segment in Section 4.1.2.4.2.

3.2.2.2.2.5 Caveats to Consider When Interpreting the Bottom Scouring and Deposition, Scouring and Deposition, Deposition of Fines, and Brightness Characteristics

There are two caveats to consider when interpreting these characteristics. One significant caveat is that scores for each characteristic depend on recent flow history. This factor has two meanings: (1) the limited time series of data for each characteristic may not capture the range of conditions and the degree of stability or instability present over time; (2) scores for these characteristics may vary depending on the time of year in which the habitat surveys were conducted. For example, the brightness characteristic is intended to represent evidence of recent bedload movement as indicated by the lack of periphyton presumably removed by mechanical action.

However, habitat surveys conducted in mid or late summer may have allowed sufficient time for regrowth of periphyton during low-flow periods.

The second caveat is that the protocol for evaluating the bottom scouring and deposition characteristics may misrepresent the type of substrate stability providing critical habitat features for aquatic receptors. The distinction lies between geomorphic stability of bottom substrates and the stability of substrate sizes biologically important to aquatic receptors. Large cobble- to boulder-sized substrate in degraded and armored channels may be quite stable, while the gravel- to small-cobble-sized substrate (3 inches in diameter and smaller) may have long since been mobilized out of the system. Similarly, an armored channel may not deposit fine-grained sediments to a significant extent, as they are quickly moved through the system.

Each caveat describes circumstances that can result in an underestimation of risk in a given CSM segment.

3.2.2.3 Water Temperature

High water temperatures can have detrimental impacts on several identified aquatic receptors. Thresholds of temperature sensitivity have been documented for fish species, particularly salmonids. Amphibians also have preferred temperatures ranges for resting, rearing, and feeding activities. Several species of aquatic macroinvertebrates are coldwater-tolerant, and shifts in temperature ranges can result in changes in community composition. Temperature tolerances of cutthroat trout are selected here as representative of conditions suitable for all aquatic receptors. The rationale for using cutthroat trout temperature tolerance as a proxy value for other receptors is that cutthroat are a keystone native species in watersheds of the Northern Rocky Mountains Ecoregion (Maret 1995; Maret et al. 1997; Omernick and Gallant 1986). Therefore, the temperature range supporting this species is believed to be generally representative of those for other aquatic species in these ecosystems. However, the temperature tolerance ranges of some species of fish and invertebrates representative of watersheds of the region are lower than that of cutthroat. This suggests that risks to these aquatic receptors from high stream temperatures may be underestimated by the tolerance ranges of cutthroat.

However, the tolerance range for cutthroat trout is used here because there are several factors that complicate calculation of risk criteria for other species of concern. Consider the examples provided by bull trout and sculpin. Although temperature tolerances for bull trout are not well defined, bull trout are known to have a lower optimal temperature range than cutthroat trout. In general, temperatures in excess of 15°C are believed to be limiting to bull trout distribution (Rieman and McIntyre 1993), although streams that exceed these temperatures during warm weather months may be used as migratory or feeding habitat during cooler weather periods. Bull trout present a diverse metapopulation structure, in which the various life history stages of distinct population segments may transit or use habitats that commonly exceed their known temperature tolerance levels during cooler weather months, while resident and rearing juvenile bull trout restrict their distribution to cooler water tributaries. The distribution of temperature monitoring locations and the timing of monitoring do not capture the full spatial and temporal distribution of bull trout population structure and life cycle stages. Further, temperatures in reference streams for CSM Units 1 and 2 regularly exceed 15°C, indicating that the monitoring locations selected may not represent the cooler water tributaries preferentially selected by bull trout. Applying the temperature tolerance ranges without more detailed information on the metapopulation structure and historical habitat usage of bull trout could then lead to an overestimation of risk. It is acknowledged that the use of the cutthroat trout tolerance range would underestimate risks to bull trout if they have population and life cycle phases present in the areas represented by temperature monitoring during summer months. This potential is addressed further in Section 4.3.2.1.3.

Several species of sculpins (*Cottus* spp.) may be or were historically present in the Coeur d'Alene River basin. These include the mottled sculpin (*C. bairdi*), the shorthead sculpin (*C. confusus*), and the slimy sculpin (*C. cognatus*). The distribution of sculpin species is expected to be more sensitive to temperatures than salmonids because they are nonmigratory, moving through all life history stages within a range of a few hundred meters (Hendricks 1997). Of these three species, the temperature tolerance of mottled sculpin is the best defined. Mottled sculpin are found in streams with summer temperatures from 13 to 19°C, with a maximum of 21°C. The range of shorthead sculpin tends to be limited to streams with lower average temperatures in summer months (7 to 16°C), but the maximum temperature tolerance of this species is not well established. Slimy sculpin are believed to prefer even cooler average summer temperatures, generally less than 15°C, again with no established maximum. These species are quite similar in appearance and habitat usage, which often leads to misidentification. In addition, these species are known to hybridize, which further complicates identification and the establishment of thermal tolerance ranges (Hendricks 1997). As with bull trout, temperatures in reference streams regularly exceed the preferred temperature ranges of slimy and shorthead sculpin, suggesting that the tolerance ranges of these species would not be useful for a reference area comparison of stream habitats. The temperature tolerance range of mottled sculpin overlaps that of cutthroat trout, although the maximum temperature range cited is one degree lower. The tolerance range of cutthroat trout is therefore used as a proxy for risk estimation for sculpins, with the understanding that this may lead to the underestimation of risks for the cooler water sculpin species if present. This potential is addressed further in Section 4.3.2.1.3.

Sources of information for evaluating the temperature measure include literature values for temperature tolerance ranges for cutthroat trout, aquatic life beneficial use criteria (BUC) for coldwater streams in Idaho, and the range of temperatures measured in suitable reference streams for CSM Units 1 and 2. An optimal temperature range of 12 to 15°C has been defined in habitat suitability indices for westslope-cutthroat trout (Hickman and Raleigh 1982). This species can tolerate brief periods with water temperatures as high as 26°C if considerable nighttime cooling takes place, and has been shown to tolerate a maximum weekly mean high temperature of 23.3°C. In general however, cutthroat do not persist in waters that regularly exceed 22°C (Eaton et al. 1995, as cited in Rahel 1999; Hickman and Raleigh 1982).

Idaho BUC stipulate that daily average temperatures must not exceed 19°C, and that instantaneous temperatures shall not exceed 22°C (IDHW 1996). These criteria are in excess of temperatures believed to be limiting to bull trout distribution. These criteria also exceed the optimal temperature range for cutthroat trout, but are below tolerance limits for this species.

The applicability of the water temperature risk criteria to conditions found in CSM Units 1 and 2 in the Coeur d'Alene River basin was validated by comparison to appropriate reference streams. Reference area conditions were also used to determine thresholds for different levels of risk. Watersheds were identified during the NRDA process as possible reference areas for riverine habitats in CSM Units 1 and 2. Suggested reference streams for CSM Unit 1 included high-gradient tributaries to the North Fork Coeur d'Alene River and the St. Joe River, and the high-gradient reaches of the St. Regis River. Reference streams identified for CSM Unit 2 include the moderate-gradient reaches of the St. Regis River, the St. Joe River, and moderate-gradient tributaries of the North Fork Coeur d'Alene River (e.g., the lower Little North Fork Coeur d'Alene River) (Hagler Bailley 1998; Stratus 1999a, 1999b).

Based on the guidelines provided above for identifying reference streams, temperatures measured in the higher-gradient reaches of the St. Regis and St. Joe Rivers are used as reference conditions for CSM Unit 1. Temperature monitoring was also conducted in Placer Creek, a high-gradient tributary of MidGradSeg01. These data are also used as reference conditions for CSM Unit 1 streams. (Placer Creek is an appropriate reference stream for CSM Unit 1 due to the lack of mining-related impacts to the stream system in this watershed. It is an ideal reference watershed for Canyon Creek in particular, due to similarities in watershed size, topography, and aspect.) Temperature monitoring was also conducted in the St. Joe River, the St. Maries River, and middle and lower reaches of the St. Regis River. The middle-gradient reaches of the St. Regis River, the St. Joe River above the confluence with the St. Maries River, and the Little North Fork Coeur d'Alene River are used as reference areas for CSM Unit 2 streams. Figures 3.2.2.3-1 through 3.2.2.3-5 display the instantaneous maximum temperatures collected during 1995 and 1996 for reference areas. Instantaneous maximum temperatures in reference streams did not exceed 18°C, with some exceptions under the warmest conditions, during the three monitoring periods.

Two candidate reference streams, the North Fork Coeur d'Alene River above Shoshone Creek and the St. Maries River, were rejected as reference areas because instantaneous maximum temperatures exceeded the 22°C BUC level. The ecological condition of the North Fork Coeur d'Alene River and the St. Maries River at the monitoring locations is not known; however, the fact that the state BUC was exceeded make these data questionable as reference values. It is illustrative that temperatures in July 1995 on the North Fork Coeur d'Alene River above Shoshone Creek (Figure 3.2.2.3-3) and on the St. Maries River (Figure 3.2.2.3-2) exceeded 22°C. In contrast, the instantaneous maximum temperature in July 1995 on the Little North Fork Coeur d'Alene River reached only 16.9°C (Figure 3.2.2.3-3). In July 1996, the warmest weather event during the 1995 and 1996 sampling periods, only one of five monitoring locations on the St. Regis River exceeded 18°C (reaching a high of 18.2°C) (Figure 3.2.2.3-4).

The 22°C threshold is defined as a break point between limiting and potentially lethal temperatures for cutthroat trout. Temperatures above 22°C are believed to be potentially lethal. Instantaneous maximum temperatures between 18 and 20°C are defined as limiting and instantaneous maximum temperatures less than 18°C are considered nonlimiting. It is assumed that instantaneous maximum temperatures below 18°C are representative of an average temperature range favorable to cutthroat trout. Therefore, temperatures above the 18°C threshold but below 22°C are assumed to be representative of average temperatures potentially limiting to aquatic receptors. Within this range, the 20°C threshold is arbitrarily selected as another temperature break point.

Risk criteria for cutthroat trout temperature tolerance are defined as follows:

- No Risk—Instantaneous high temperatures have not exceeded 18°C and are considered to be nonlimiting.

- Low Risk—Instantaneous temperatures have exceeded 18°C but not 20°C during high temperature events; these levels may cause avoidance responses in salmonids and may be limiting to survival during some life history stages.

- Moderate Risk—Instantaneous temperatures have exceeded 20°C but not 22°C during high temperature events. These levels may also cause avoidance responses and reduced survival while limiting the availability of suitable refuge microhabitats.

- High Risk—Instantaneous temperatures have exceeded 22°C during high temperature events, a level considered potentially lethal to salmonids.

The 18°C threshold for no risk versus low risks to cutthroat trout is based on an assumed relationship between the instantaneous maximum temperatures and daily average temperatures. The assumption applied here is that this temperature represents the average temperature for the upper end of the optimal range for this species, and it is within observed conditions in reference streams. Similarly, it is assumed that the temperature threshold for each escalating risk level is associated with increasingly detrimental effect. The 22°C BUC threshold is selected as a reliable indicator of high risks to aquatic receptors. As discussed, the temperature data used in this analysis were the result of continuous temperature monitoring, and they therefore represent the true maximum temperatures recorded at given monitoring locations. The data provided for this analysis were summarized to show the high and average temperatures at a given location by month, as shown in Tables F-3.1.1.2.2.3-1 to -6 in Appendix F (Stratus 1999a, 1999b).

3.2.2.4 [Section deleted]

3.2.2.5 Habitat Suitability Index Model for the Riparian Habitat

Results of the HSI model for assessment segments was evaluated by comparison to reference area conditions. Three riparian habitat reference areas were identified as part of the natural resource damage assessment (NRDA) (Hagler Bailly 1995): Canyon Creek upstream of Burke near Sawmill Gulch, Ninemile Creek upstream of the East Fork Ninemile Creek confluence, and the Little North Fork of the North Fork Coeur d'Alene River. Reference areas were selected based upon similarity of major nonmining environmental factors that affect the potential plant growth and vegetation community development in the reference areas, and that would be expected to control plant growth and vegetation community development in the assessment area (LeJeune and Cacela 1999). Because of the similarity in vegetative characteristics among the three reference areas (see Section 3.1.1.2.2.10), the areas were pooled to form a single composite reference area for comparison to assessment segments. The composite reference area is applicable to all segments in CSM Units 1 and 2. A suitable reference area was not available for CSM Unit 3.

It should be noted that the Canyon Creek reference area had been exposed to mining-related wastes, though to a lesser degree than downstream sites (LeJeune and Cacela 1999). Even though the Canyon Creek reference sites do not represent a true control, they were retained for analysis and comparison to assessment sites as a conservative estimate of unexposed reference site.

Two techniques were be used to compare assessment segment to reference area HSI model results. Box-and-whisker plots (boxplots) were used to visually compare data. Boxplots are a common graphical method used to describe data. Boxplots simultaneously display the full range of the data as well as key descriptive statistics. Figure 3.2.2.10.1-1 shows an example boxplot composed of a central box divided by a horizontal line (which represents the median values of the data set) and two lines extending out from the box (called the whiskers). The length of the central box indicates the spread of the central 50 percent of the data, while the lengths of the whiskers show the extent that measurements are spread out below and above the central 50-percent box.

The second technique used to compare HSI data from assessment segment to reference areas is the Mann-Whitney nonparametric test. The Mann-Whitney test was selected because the assumption of normality did not hold true for all sample populations. This prohibited the use of parametric statistical techniques such as the analysis of variance or Students *t*-test. The null hypothesis for the Mann-Whitney was that the medians of two sample populations are statistically indistinguishable. The Mann-Whitney statistic (two-tailed) was calculated using SYSTAT®9 and a statistically significant difference was defined at the $p = 0.05$.

3.2.2.6 Suspended Solids

Suspended solids concentrations in the lower Coeur d'Alene River, the lateral lakes, and Coeur d'Alene Lake were ranked according to their potential for association with adverse effects on fish. The rankings are derived from Newcombe and Jensen (1996), who developed a series of regression equations relating the concentration of suspended solids in water (mg/L) and the duration of exposure to a given solids level to the severity of an adverse effect. Regressions are of the general form

$$z = a + b(\ln x) + c(\ln y)$$

Where:

z = the severity of adverse effect score (scale of 0 to 15)

x = duration of exposure to suspended solids (hours)

y = concentration of suspended solids (mg/L)

a = y-intercept of the regression

b and c = slope coefficients

Newcombe and Jensen (1996) developed a 15-point scale defining the severity of adverse effects from suspended solids. Within their 15-point scale, they identified four major groupings of severity of adverse effect: no effect (rating of 0 to 1), behavioral effects (rating of 1 to 3), sublethal effects (rating of 4 to 8), and lethal and paralethal effects (rating of 9 or greater). For purposes of this risk assessment, we define three risk levels as follows:

- No or low potential for ecological risk—no or short-term, reversible adverse effects; severity of effect score of 0 to 5
- Moderate potential for ecological risk—moderate to major sublethal effects; severity of effect score of 6 to 9
- High potential for ecological risk—increased mortality of aquatic species; severity of effect score of 10 to 14

The revisions we have made to the four severity-of-adverse-effect groups of Newcombe and Jensen (1996) were based on our review of their 15-point scale. We observed that severity-of-effect scores of 0 to 2 could not be achieved for only suspended solids concentration exposure of 24 hours, and that severity-of-adverse-effect ratings of 0 to 5 were somewhat arbitrarily defined by Newcombe and Jensen (1996) but represented short-term, reversible effects. A severity-of-adverse-effect score of 9 was not associated with increased mortality, thus its inclusion in our moderate to major sublethal effect category, instead of Newcombe and Jensen's (1996) lethal category.

Effects of suspended solids were evaluated for three receptors: juvenile and adult salmonid fishes, eggs and larvae of salmonid and nonsalmonid fishes, and adult nonsalmonid fishes. The regression equations from Newcombe and Jensen (1996) were employed to calculate severity of effects and are shown in Equations 1, 2, and 3.

Equation 1:
Juvenile and Adult Salmonids

$$z = 1.0642 + 0.6068(\ln x) + 0.7384(\ln y)$$

Equation 2:
Eggs and Larvae of Salmonids and Nonsalmonid Fish

$$z = 3.7466 + 1.0946(\ln x) + 0.3117(\ln y)$$

Equation 3:
Adult Nonsalmonid Fish

$$z = 4.0815 + 0.7126(\ln x) + 0.2829(\ln y)$$

Because the value chosen for the exposure duration term in the above regressions has a major effect on the calculated severity of effect score and the risk subsequently estimated, two default exposure durations were chosen for use. The USGS suspended solids data are intended to be representative of the concentration on the day the sample was collected; thus, a 24-hour exposure duration was chosen to evaluate risks on a daily basis. Newcombe and Jensen (1996) set the boundary between short-term and long-term reduction in feeding success at a 2-hour exposure duration. A 2-hour exposure duration was chosen to evaluate risks on a more instantaneous risk basis, or from short-term, transient elevations in suspended solids concentrations. The regression equations are intended to estimate risks for a class of receptors, such as juvenile and adult salmonids, as opposed to risks for a single species, such as bull trout.

EPA has a narrative ambient water quality criterion for suspended solids intended to protect freshwater fish and other aquatic life (USEPA 1986). The criterion states that suspended solids should not reduce the depth of the compensation point for photosynthetic activity by more than 10 percent from the seasonally established norm. As we are unaware of any information about the compensation point for the Coeur d'Alene River basin, we could not quantitatively evaluate suspended solids risks using the EPA suspended solids ambient water quality criterion (USEPA 1986).

A reference site was identified on the St. Joe River at Calder, Idaho, for comparison to the assessment segments on the main stem Coeur d'Alene River and the Spokane River at Post Falls dam. The St. Joe River basin has received much less mining activity than the Coeur d'Alene River basin, but has similar levels of other human activity (e.g., logging, agricultural) (Stratus 1999). Therefore, the suspended solids concentrations at Calder are assumed to be indicative of concentrations expected to be found on the main stem Coeur d'Alene River and the Spokane River at Post Falls dam in the absence of mining-related impacts.

3.2.2.7 [Section deleted]

3.2.2.8 Sediment Deposition Rate

The Post Falls dam on the Spokane River controls the water elevation of the Spokane River upstream of the dam, as well as the water elevation of both Coeur d'Alene Lake and the Coeur d'Alene River as far upstream as Rose Lake. Rose Lake is located in Segment 2 of the main stem Coeur d'Alene River, and is the farthest upstream of the lateral lakes on the river.

Several investigators (Bender 1991, Rember et al. 1993, Rabbi 1994) have observed a substantial decrease in sedimentation rates in the Coeur d'Alene River and the lateral lakes since the installation of sedimentation ponds at mining and mineral processing sites throughout the basin in 1968 and 1969. Because of this decrease in sedimentation rate after 1969, annual average sediment deposition rates since the beginning of mining activities in the basin in the 1880s would overstate present day deposition rates, and therefore any ecological risks associated with sediment deposition. Risks have therefore been calculated on sedimentation rates observed or calculated for the period since 1969.

Sedimentation rates in waters of the Coeur d'Alene River basin have been estimated from sediment core data through the use of one of the following three estimation methods:

- Radiodating methods using cesium 137 and/or lead 210
- Identification of stratigraphic markers in cores; e.g., the ash layer resulting from either the 1980 eruption of Mt. St. Helens or the 6,700 years before present (B.P.) eruption of Mt. Mazama
- Changes in mining-related metal concentrations of cores with depth

Two approaches were used to establish sedimentation rates that would be expected to occur in the Coeur d'Alene River basin in the absence of impacts from mining-related hazardous substances. First, sediment cores that recovered complete historical records of sedimentation from before mining activities took place in the basin were used to establish sediment deposition rates. Pre-mining sediment deposition rates were taken to indicate normal conditions in the Coeur d'Alene drainage in the absence of any mining impacts. Because as the pre-mining sediment deposition rates are the historical norms for the system, native aquatic species present in the basin prior to the start of mining have been be adapted to the historical sedimentation rates. Second, deposition rates expected to occur in the absence of impacts from mining-related hazardous substances were derived from the use of reference areas.

3.2.2.9 Spatial Distribution and Connectivity

As discussed in Section 2.4.3.3, there are connectivity relationships within and between riparian and riverine habitats at various levels. The spatial distribution and connectivity measure is an examination of the connectivity within riverine and riparian habitats at larger spatial scales (i.e., CSM segment to sub-basin scales). The measure of effect of spatial distribution and connectivity is a "best professional judgment" based integration of previously examined measures of ecosystem and receptor characteristics for riverine and riparian habitats as described below.

For riverine habitats in CSM Units 1, 2, and 3, the measures of ecosystem and receptor characteristics considered here include bank stability, substrate composition and mobility, and water temperature. For riverine habitat, the focus of the spatial distribution and connectivity measure is longitudinal connectivity, as described in Section 2.4.3.3, at meso-level (e.g., segment to segment) and macro-level (e.g, South Fork Coeur d'Alene River watershed) scales. For riparian habitats, the habitat suitability index and riparian vegetation measures are considered to be the equivalent of longitudinal connectivity, representative of the continuity of riparian patch habitats providing migratory corridors for identified receptors, habitat functions, and other ecological functions such as large woody debris recruitment.

Additional information pertinent to the ecological effects characterization for the Spatial Distribution and Connectivity Measure is provided in Appendix E.

3.2.2.10 Riparian Vegetation

3.2.2.10.1 Analysis of Riparian Vegetation

Riparian vegetation was evaluated by comparing the vegetative characteristics of assessment segments to the vegetative characteristics of the reference areas. Vegetative data were obtained from the NRDA line transect study (Hagler Bailly 1995). Data used in the risk assessment included cover (expressed in meters) and species richness for the herb, shrub, and tree height classes and bare ground (expressed in meters). Reference areas from Canyon Creek upstream of Burke near Sawmill Gulch, Ninemile Creek upstream of the East Fork Ninemile Creek confluence, and the Little North Fork of the North Fork Coeur d'Alene River were pooled into a single reference area dataset (see Appendix E). Data from the pooled reference area were used to evaluate the condition of the riparian vegetation in all segments in CSM Units 1 and 2. A suitable reference area was not available for CSM Unit 3.

Two techniques were used to compare the vegetative characteristics of assessment segments to the reference area. Box-and-whisker plots (boxplots) were used to visually compare the vegetative characteristic data. A boxplot is a graphical method commonly used to describe data; it simultaneously displays the full range of the data as well as key descriptive statistics. Figure 3.2.2.10-1 is an example boxplot.

The second technique used to compare riparian vegetation characteristics from assessment segments and the pooled reference area is the Mann-Whitney nonparametric test. The Mann-Whitney test (2-tailed test) was selected because the assumption of normality did not hold true for all sample populations, and this prohibited the use of parametric statistical techniques such as the analysis of variance or Students t test. The null hypothesis for the Mann-Whitney test was that the medians of two sample populations (i.e., the reference area and assessment area segment) are statistically indistinguishable. The Mann-Whitney statistic was calculated using SYSTAT®, Version 9.0 and a statistically significant difference was defined at the $p = 0.05$.

In addition to the evaluation approach described above, information provided in the modified BLM vegetative cover map (Stratus 2000b), stream habitat survey (Wesche 1999), and November 1999 field visit was used to augment results of the NRDA line transect study (Hagler Bailly 1995) and fill in gaps in spatial coverage as required. When appropriate, results of the line transect study for one segment were extrapolated to adjacent segments. Justification is provided in Section 4.1.2.2.10.1 for specific segments in which the extrapolations were made.

Cover and species richness for the herb and shrub height classes, and bare ground cover were selected as the primary determinants of the riparian vegetation condition. Tree cover and species richness were not commonly found in either the assessment or reference sites. Variability in vegetative characteristics among sample locations within the reference areas is relatively high (Table 3.1.1.2.2.10-1). Such variability is natural and attributable to localized differences in growing conditions such as soil texture, water availability, and competition. Since variability within the reference area is high, differences in vegetative characteristics between assessment and reference sites can be discerned only at a coarse level. In this risk assessment, the available data were used to rate the condition of the riparian vegetation in each segment as either degraded or not degraded. A degraded condition signifies that the vegetative characteristics found in an assessment segment are distinctly impaired in comparison to the reference area. The condition of the riparian vegetation for any assessment segment was considered degraded when:

- At least one herb and one shrub vegetative characteristic, and bare ground cover for an assessment segment are statistically different (i.e., lower cover and species richness, and higher bare ground cover) from the reference area at $p < 0.05$ using the Mann-Whitney test and

- There are distinct observable differences between the assessment segment and reference area as demonstrated by the box plots for the set of vegetative characteristics showing statistical significance (i.e., the hinges of the box plots representing the 25th and 75th percentiles do not overlap).

3.2.2.10.2 Comparison of Riparian Vegetation and Soil Characteristics

The relationships between riparian vegetation and soil characteristics were investigated. NRDA data (Hagler Bailly 1995) were used in the analysis and included the reference and assessment area sampling sites. Reference and assessment area data from CSM Units 1 and 2 were used in this analysis because these sites had similar cover types (i.e., all vegetated sites were classified as either deciduous shrubland or grassland and forbs) (Table F-3.1.1.2.2.10-5 in Appendix F) and were assumed to contain similar plant assemblages. It was further assumed that these plant assemblages present in CSM Units 1 and 2 would respond to changes in soil characteristics in a similar manner. Data from CSM Unit 3 were not used in the analysis because the primary cover types for many of the sampling sites in CSM Unit 3 differed from those in CSM Units 1 and 2 (i.e., 18 of 40 riparian vegetation sampling sites in CSM Unit 3 were classified as wetlands), the dominant vascular plant species in CSM Unit 3 differed from those in CSM Units 1 and 2, and results of analyses of vegetative characteristics did not show the riparian vegetation in CSM Unit 3 was degraded.

Vegetative characteristics included in the evaluation were number of species and cover (m) for herb, shrub, and tree height classes, and bare ground cover. Soil characteristics included in the evaluation were chemical concentrations of arsenic, cadmium, copper, iron, manganese, lead, zinc, and nitrate [NO3]; soil texture (clay, silt, and sand); soil pH; and soil organic matter. Sulfur and neutralization potential were excluded from the analysis because data were available for only a limited number of samples (i.e., 14 of 68 samples sites) in CSM Units 1 and 2.

Spearman's rank order correlation coefficients were calculated for all vegetation and soil characteristics comparisons using the raw data presented in Tables F-3.1.1.2.2.10-5 and 3.1.1.2.2.10-6 in Appendix F for all sampling sites within CSM Units 1 and 2. Spearman's statistic was used because the distribution of most of the variables within the data set was not normal (Zar 1996). All statistical comparisons of riparian vegetative and soil characteristics were performed using SYSTAT®, version 9.0.

Regression analysis was used to investigate how well soil characteristics described variability in vegetative characteristics. A stepwise (forward) multiple linear regression analysis was conducted on each dependent variable (i.e., vegetative characteristic) and the set of independent variables (i.e., soil characteristics). An underlying assumption of regression analysis is that the data fit a normal distribution and data were transformed to meet this assumption. Soil characteristics data were transformed using standard practices (Zar 1996); soil analytical chemistry data were log transformed (log10) and percentage data (i.e., soil texture and organic matter) were arcsine square root transformed. The distributions for the vegetative characteristics raw data were evaluated and none were found to fit a normal distribution. The species richness data approximated a normal distribution when a square root transformation was used, but none of the standard data transformations resulted in an approximation of the normal distribution for the vegetative cover characteristics. Therefore, no transformation was applied to the cover data in the regression analyses. Implications of using data with non-normal distributions in the regression analysis are discussed in the uncertainty analysis (Section 4.3.2.3.10).

3.2.3 Aquatic Stressor-Response Profile

Stressors to aquatic plants and animals include (variously) elevated concentrations of cadmium, copper, lead, and zinc in all CSM Units. Cumulative response profiles of toxicity of metals to aquatic animals present in the Coeur d'Alene River basin indicate that concentrations equal to the chronic national ambient water quality criteria (CCC) should be protective of most aquatic animals. Site-specific toxicity testing (Section 3.2.1.2) indicates results that are in general agreement with the effects predicted by the concentrations of the metals in basin surface waters and the effects predicted by the cumulative response profiles (Section 3.2.1.1).

Sampling of fish and benthic invertebrates in the Coeur d'Alene River basin, and comparison of the sampling results with sampling done in reference areas indicates that reduced populations of fish and, to a lesser extent, benthic invertebrates (Section 3.2.1.3), generally reflect the distribution of chemical stressors in water and sediment (Section 3.2.1.1).

3.2.4 Acute Lethality Testing with Benthic Invertebrates

EVS (1996b, 1997b, 1998) did site-specific toxicity tests with benthic invertebrates collected from the SFCDR. Various species were individually exposed to either Cd, Pb, or Zn in LNF water. Invertebrates collected from the SFCDR were relatively tolerant of Cd, Pb and Zn exposures (Table 3.2.1.2-5). Effects concentrations normalized to a hardness of 50 mg/L were at least one to two orders of magnitude greater than AWQC values.

Results from these site-specific toxicity tests suggest that toxicity to Coeur d'Alene invertebrates occurs at metal concentrations well above ALC values. EVS used invertebrates collected from the SFC DR upstream of Mullan, and exposed the invertebrates to SFCDR water spiked with Cd, Zn, or Pb. However, the thresholds produced from these tests may not be the most sensitive thresholds for Coeur d'Alene River basin invertebrates for the following reasons:

The test results are not indicative of toxicity to metal-sensitive invertebrate species. For example, of the five invertebrate species used in Pb toxicity testing, the most sensitive species was the mayfly *Baetis tricaudatus* (EVS 1997). Although many mayfly species are sensitive to metals, *Baetis* are known to be relatively tolerant of metal toxicity (Beltman et al. 1999). In fact, *Baetis tricaudatus* was one of the first species to recognize the SFC DR in the early 1 970s, when only a few invertebrate species could survive in the river (Stokes and Ralston 1972; Savage and Rabe 1973; Funk et al. 1975). Therefore, the tests most likely did not use species representative of metal-sensitive invertebrates.

The tests used invertebrates collected from the South Fork Coeur d'Alene River in areas potentially downstream of mining activity. Therefore, the organisms used in the tests may have been preselected for metal tolerance.

Several of the tests did not show a consistent dose-response relationship, making their interpretation difficult.

In addition to site-water *in situ* toxicity tests with rainbow trout in the SFCDR, Dames and Moore (1989) also did site-specific 7-day toxicity tests with *Ceriodaphnia dubia* with site water collected from the same locations on the SFC DR. Ceriodaphnia were exposed to 0, 0.1, 0.3, 1, 1.5, 3, 6, 13, 25, 50, and 100 percent site water mixed with clean laboratory water (as appropriate) under controlled laboratory conditions. LC_{50} values ranged from 0.1 to 6.1 percent site water at water hardness ranging from 67 to 168 mg/L (Table 3.2.1.2-6). When normalized to a water hardness of 50 mg/L, metal concentrations at the LC_{50} effect ranged from 0.11 to 0.36 μg Cd/L, from 0.03 to 0.46 μg Pb/L, and from 19.3 to 95.2 μg Zn/L (Table 3.2.1.2-7). These concentrations fall below the dissolved AWQC for Cd and Pb and are within a factor of 2 (both above and below) the dissolved Zn AWQC. No mortality was observed in 100 percent NFCDR site water (Dames and Moore 1989). These acute toxicity results suggest that the toxicity of a mixture of Cd, Pb, and Zn is greater than the toxicity based on single metal exposures and highlight that the site water collected from the SFCDR is acutely lethal to zooplankton at mixed metal concentrations at or near the applicable AWQC.

4.0 Risk Characterization

SECTION 4.0 RISK CHARACTERIZATION

does not match table of contents

4.1 RISK ESTIMATION

needs some introduction

4.1.1 Single-Chemical Toxicity

has –
how about saying HQ < 10

4.1.1.1 Surface Water

Table 4.1.1.1-1 lists the 17 CSM segments that do not have sample results with exceedances of an acute or chronic surface water hazard quotient (HQ) of 10. CSM segments associated with sample results that exceed either an acute or chronic HQ of 10 are listed in Table 4.1.1.1-2; this table also includes the calculated percentage of samples that exceed a HQ of 10. These percentages are shown graphically for acute and chronic exposures in Figures 4.1.1.1-1 and 4.1.1.1-2, respectively. Inspection of the first figure (for acute exposure) suggests that zinc and cadmium are of most concern. Inspection of the second figure (for chronic exposure) suggests that zinc, cadmium, and lead exhibit the highest percentages and are thus of most concern. The percentage of samples exceeding either the acute or chronic copper HQ raises much less concern. The tables and figures discussed earlier in this paragraph are based on the summary statistics for acute and chronic surface water hazard quotients presented in Table 4.1.1.1-4. A detailed discussion of the process used to calculate these surface water HQs and apply a hardness-correction factor is included in Appendix G.

There were no CSM segments with all sample results indicating an acute or chronic surface water HQ of less than one (Table 4.1.1.1-1). CSM segments associated with sample results that exceed either an acute or chronic HQ of one are listed in Table 4.1.1.1-3; this table also includes the calculated percentage of samples that exceed a HQ of 1. These percentages are shown graphically for acute and chronic exposures in Figures 4.1.1.1-3 and 4.1.1.1-4, respectively. Inspection of both of these figures suggests that all of the chemicals included in this portion of the evaluation (in this case, cadmium, copper, lead, and zinc) are more-or-less equal in terms of the percentage exceeding the criteria (i.e., 1). The tables and figures discussed earlier in this paragraph are based on the summary statistics for acute and chronic surface water hazard quotients presented in Table 4.1.1.1-4. A detailed discussion of the process used to calculate these surface water HQs and apply a hardness-correction factor is included in Appendix G.

4.1.1.2 Sediment

Table 4.1.1.1-5 lists the two CSM segments that do not have sample results with exceedances of an acute or chronic surface sediment HQ of 10. CSM segments associated with sample results that exceed an sediment HQ of 10 are listed in Table 4.1.1.1 6; this table also includes the calculated percentage of samples that exceed an HQ of 10. These percentages are shown graphically in Figure 4.1.1.1-5. Inspection of the figure suggests that lead and silver are of primary concern with mercury, zinc, and possibly cadmium of secondary concern. The tables and figures discussed earlier in this paragraph are based on the summary statistics presented in

Table 4.1.1.1-8. A detailed discussion of the process used to calculate these sediment HQs is included in Appendix I.

CSM segments associated with sample results that exceed asediment HQ of 1 are listed in Table 4.1.1.1 7; this table also includes the calculated percentage of samples that exceed an HQ of 1. These percentages are shown graphically in Figure 4.1.1.1-6. Inspection of the figure suggests that all of the listed analytes are of approximately equal concern at this criterion level. The tables and figures discussed earlier in this paragraph are based on the summary statistics presented in Table 4.1.1.1-8. A detailed discussion of the process used to calculate these sediment HQs is included in Appendix I.

4.1.1.2.4 Amphibians

The minimum, 5th, 10th, 20th, and 50th (median) percentiles of the effects distributions for amphibians (Section 3.2.1.1.4) were used to compare to the maximum, 90th, and 80th percentile of the water concentration in the Couer d'Alene River basin. The resulting HQ was used to determine potential for risk to amphibians. Any HQ>1 is indicative of potential risk to amphibians within the CDA Basin.

Risk estimates were calculated for four amphibian species in the CDA Basin. Three of these species, the Idaho (Pacific) giant salamander (*Dicamptodon aterimus*), the Coeur d'Alene salamander (*Plethodon idahoensis*), and the Spotted frog (*Rana pretiosa*) are species of concern and are evaluated at the individual level. The fourth species, the Long-toed salamander (*Ambystoma macrodactylum*) is evaluated at the population level.

Initial LOEC-based HQs for the minimum, 5th, 10th, and 20th percentiles and the median of the effect distribution were calculated for amphibians using LOECs based on embryo and larval age classes. Three exposure point concentrations were used in the HQ calculation to compare to the above percentiles of the effect distribution: the maximum water concentration, the 90th percentile of the water concentration, and the 80th percentile water concentration. The results of this analysis are presented in Table 4.1.1.1.4-1.

The three species of concern are evaluated at the individual level. For individual-level comparisons, the 90th percentile of the water concentration was compared to the 10th percentile of the effect distribution. The embryo LOEC HQ>1 for cadmium in the NineMile and Box segments only. There are no larval risks associated with cadmium. For copper, both the embryo and larval LOEC HQ>1 for LCDRSeg4. There are no risks to sensitive species from exposure to lead (no HQs>1) in any segment. For zinc, both embryo and larval LOEC HQs>1 in the BvrCrk, CCSeg, MoonCrk (larval only), Ninemile, PineCrk, PrchCrk (larval only), UpSFCDR1 (larval only), Box, MdGrdSg, LCDRSeg2 (larval only), LCDRSeg4 (larval only), and LCDRSeg5 (larval only).

The long-toed salamander (*Ambystoma macrodactylum*) is evaluated at the population level. For population-level comparisons, the 90th and 80th percentiles of the water concentration were compared to the 20th percentile of the effect distribution. For cadmium, the embryo LOEC HQ>1, at both the 90th and 80th percentiles of the water concentration, in the Box segment of the CDA Basin. No larval LOEC HQs>1 for cadmium. Copper embryo and larval LOEC HQs>1 at the 90th percentile of the water concentration in LCDRSeg4. There are no HQs>1 in any other segment or at the 80th percentile of the water concentration. There are no risks to the Long-toed salamander from exposure to lead in any segment at the population level. For zinc, both embryo and larval LOEC HQs>1, at the 90th percentile of the water concentration, in the BvrCrk, CCSeg, Ninemile, PineCrk, Box, and MdGrdSg (embryo only). At the 80th percentile of the water concentration, both the embryo and larval LOEC HQs>1 in the CCSeg (embryo only), Ninemile, PineCrk, and Box segments.

For those constituents that had an HQ>1 using the 10th or 20th percentile of the effect distribution, an additional analysis was conducted by comparing the median effect concentration to the 90th or 80th percentile of the water concentration. Zinc was the only metal that has HQs>1 (for both sensitive species and population-level effects). The embryo LOEC HQs>1, at the 90th percentile of the water concentration, at BvrCrk, CCSeg, Ninemile, PineCrk, and Box segments. Using the 80th percentile of the water concentration, Ninemile, PineCrk, and Box segments still have HQs>1.

4.1.1.2.5 Terrestrial Plants

The minimum, 5th, 10th, 20th, and median percentiles of the effects distributions for plants (Section 3.2.1.1.5) were compared to the maximum, 90th, and 80th percentile of the soil concentration in the CDA Basin. The resulting HQ was used to determine potential for risk to terrestrial plants. Any HQ>1 is indicative of potential risk to terrestrial plants within the CDA Basin.

Risk estimates were calculated for six plant species in the CDA Basin. Three of these species, the Ute ladies'-tresses (*Spiranthes diluvialis*), the Porcupine sedge (*Carex hystericina*), and the Prairie cordgrass (*Spartina pectinata*) are special-status species (the former is federal T&E; the later two are state sensitive), and are assessed at the individual level. The three remaining species, the cottonwood (*Populus* spp.), Willow (*Salix* spp.), and the Rocky Mountain maple (*Acer glabrum*) are assessed at the population-level. The plant community as a whole is also assessed at the community-level.

Initial HQs for the minimum, 5th, 10th, and 20th percentiles, and the median of the effect distribution were calculated for plants; using NOELs, LOECs, and EC10, EC20, and EC30 of the toxicity data. Three exposure point concentrations were used in the HQ calculation to compare to the above percentiles of the effect distribution: the minimum soil concentration, the 90th percentile of the soil concentration, and the 80th percentile of the soil concentration. The results of this analysis are presented in Table 4.1.1.1.5-1.

The arsenic, cadmium, copper, lead, and zinc NOEC HQ>1 for special-status species (evaluated at the 90th percentile soil concentration and the 10th percentile of the effect distribution) in all segments of the CDA Basin. The special-status species LOEC, EC10, EC20, and EC30 HQs>1 for all metals in all segments of the CDA Basin, with the exception of the cadmium EC30 for

BigCrk, the copper LOEC for BigCrk, CDA Lake, and SPKRSg, and the lead EC30 for CDA Lake. The HQs were elevated in all segments, with the exception of CDALake and SPKRSeg. While still exhibiting HQs>1 for many of the endpoints, the magnitude of the exceedance was less than any of the other segments. The HQs for the 90th percentile of the soil concentration and the 10th percentile of the effect distribution ranged from slightly above 1 to 2315. Using the 80th percentile of the soil concentration did not substantially lower any of the HQs. The HQs>1 for all metals in many of the segments using the median percentile of the effect distribution.

The three plant species evaluated at the population level and the plant community as a whole, were assessed using the 90th percentile of the soil concentration at the 20th percentile of the effects distribution. The arsenic, cadmium, copper, lead, and zinc NOEC, LOEC, EC10, EC20, and EC30 HQs >1 for all segments of the CDA Basin, with the exception of arsenic and copper LOECs and the cadmium EC30 and LOEC for BigCrk; the cadmium EC30 for PineCrk; the arsenic and copper LOECs, cadmium EC30 and LOEC, , and lead EC30 for CDA Lake. Similar results were obtained (the same segments exhibited elevated HQs) using the 80th percentile of the soil concentration at the same percentile (20th) of the effect distribution. The HQs for the 90th percentile of the soil concentration and the 20th percentile of the effect distribution ranged from slightly above 1 to 435. The HQs>1 for all metals in many of the segments using the median percentile of the effect distribution.

4.1.1.2.6 Soil Invertebrates

The minimum, 5th, 10th, 20th, and median percentiles of the effects distributions for soil invertebrates (Section 3.2.1.1.6) were compared to the maximum, 90th, and 80th percentile of the soil concentration in the CDA Basin. The resulting HQ was used to determine potential for risk to soil invertebrates. Any HQ>1 is indicative of potential risk to soil invertebrates within the CDA Basin.

Risk estimates for mixed terrestrial invertebrates were calculated at the community level. Initial HQs for the minimum, 5th, 10th, and 20th percentiles, and the median of the effect distribution were calculated for soil invertebrates using NOECs and LOECs from earthworm toxicity data. Three exposure point concentrations were used in the HQ calculation to compare to the above percentiles of the effect distribution: the maximum soil concentration, the 90th percentile of the soil concentration, and the 80th percentile of the soil concentration. The community level was assessed at the 90th and 80th percentile of the soil concentration using the 20th percentile of the effects distribution. The results of this analysis are presented in Table 4.1.1.1.6-1.

The copper NOEC and the lead and zinc NOEC and LOEC HQs>1 for the BigCrk Basin, using both the 90th and 80th percentiles of the soil concentration at the 20th percentile of the effect distribution. All other metal NOEC and LOEC HQs<1 for the BigCrk Basin. For all other segments, arsenic, cadmium, copper, lead, and zinc NOEC and LOEC HQs>1 for both the 90th and 80th percentiles of the soil concentration. The highest magnitude of the HQs is in the MdGrdSg, UpSFCDR1, NineMile, and CCSeg. Each of these segments have HQs>100. By using the median percentile of the effect distribution, the HQs decrease proportionally; however, all segments have HQs>1 for one or more metals.

Because there were many HQs>1, the HQs<1 are listed by segment as follows: the arsenic LOEC in the Ninemile segment at both the 90th and 80th percentiles of the soil concentration; the cadmium LOEC in the Ninemile segment at the 80th percentiles of the soil concentration; the cadmium LOEC in the PineCrk segment at both the 90th and 80th percentiles of the soil concentration; the cadmium NOEC and LOEC and copper LOEC in the PineCrk segment at the 80th percentile of the soil concentration; the cadmium LOEC in the MdGrdSg at the 80th percentile of the soil concentration; the cadmium LOEC in the LCDRSeg1 at both the 90th and 80th percentiles of the soil concentration; the arsenic NOEC and LOEC in both the CDALake and SPKRSg at both the 90th and 80th percentiles of the soil concentration; the cadmium NOEC and LOEC in the CDA Lake at both the 90th and 80th percentiles of the soil concentration; the copper NOEC at the CDALake at the 80th percentile of the soil concentration and LOEC at the 90th percentile of the soil concentration; the lead LOEC in the CDALake at the 80th percentile of the soil concentration; and the cadmium and copper LOECs in the SPKRSg at both the 90th and 80th percentiles of the soil concentration.

discussions are really hard to read? - table would be a better presentation with summary text

4.1.1.2.7 Microbial Processes

The minimum, 5th, 10th, 20th, and median percentiles of the microbial effects distributions (Section 3.2.1.1.7) were compared to the maximum, 90th , and 80th percentile of the soil concentration in the CDA Basin. The resulting HQ was used to determine potential for risk to microbial processes within the CDA Basin. Any HQ>1 is indicative of potential risk to microbial processes within the CDA Basin.

Risk estimates for microbial processes were calculated at the community level. Initial HQs for the minimum, 5th, 10th, and 20th percentiles, and the median of the effect distribution were calculated for microbial processes using NOECs and LOECs from microbe toxicity data. Three exposure point concentrations were used in the HQ calculation to compare to the above percentiles of the effect distribution: the maximum soil concentration, the 90th percentile of the soil concentration, and the 80th percentile of the soil concentration. The community-level was assessed at the 90th and 80th percentile of the soil concentration using the 20th percentile of the effects distribution. The results of this analysis are presented in Table 4.1.1.1.7-1.

Arsenic, cadmium, copper, lead, and zinc NOEC and LOEC HQs>1 in at least one, and typically many, of the segments in the CDA Basin. The 90th and 80th percentiles of the soil concentration have similar results, with the HQs slightly lower, but typically above one, in the 80th percentile of the soil concentration. Using the median percentile of the effect distribution decreases the HQs proportionally, however, all metal HQs>1 in most segments. The highest magnitude of the HQs is in CCSeg, NineMile, UpSFCDR1, LCDRSeg2, LCDRSeg3, LCDRSeg4, LCDRSeg5, LCDRSeg6, with the majority of the risk contributed from zinc and to a lesser extent, lead. The UpSFCDR1 segment has the highest magnitude of HQs.

Cadmium (NOEC only), lead, and zinc NOEC and LOEC HQs>1 for both the 90th and 80th percentiles of the soil concentration in the BigCrk segment. Cadmium (NOEC only), copper, lead, and zinc NOEC and LOEC HQs>1 for both the 90th and 80th percentiles of the soil concentration in the CCSeg segment. Cadmium (NOEC only), copper (NOEC only), lead, and zinc NOEC and LOEC HQs>1 for both the 90th and 80th percentiles of the soil concentration in the NineMile, MdGrdSg, and LCDRSeg1 segments. Arsenic, cadmium (NOEC only), copper (NOEC only), lead, and zinc NOEC and LOEC HQs>1 for the 90th percentile of the soil concentration in the PineCrk segment. Lead and zinc NOEC and LOEC HQs>1 for the 80th percentile of the soil concentration. All metals (with the exception of the arsenic NOEC in the 80th percentile of the soil concentration) exceeded the NOEC and LOEC HQs>1 for both the 90th and 80th percentiles of the soil concentration in the UpSFCDR1 segment. All metal NOECs and LOECs, with the exception of the copper LOEC, HQs>1 for the 90th percentile of the soil concentration in the LCDRSeg2 and LCDRSeg3 segments. Cadmium (NOEC only), copper (NOEC only), lead and zinc NOECs and LOECs HQs>1 for 80th percentile of the soil concentration in the LCDRSeg2 and LCDRSeg3 segments. Arsenic, cadmium (NOEC only), copper NOEC only), lead, and zinc NOECs and LOECs HQs>1 for the 90th percentile of the soil concentration in the LCDRSeg4, LCDRSeg5, and LCDRSeg6 segments. Arsenic (LCDRSeg 6 only), cadmium (NOEC only), copper (NOEC only), lead, and zinc NOECs and LOECs HQs>1 for the 80th percentile of the soil concentration in the LCDRSeg4, LCDRSeg5, and LCDRSeg6. Cadmium (NOEC only), lead (NOEC only), and zinc NOECs and LOECs HQs>1 for the 90th percentile of the soil concentration in the CDALake and SPKRSeg. Zinc NOEC and LOEC HQs>1 for the 80th percentile of the soil concentration in the CDALake. Cadmium (NOEC only), lead (NOEC only), and zinc NOECs and LOECs HQs>1 for the 80th percentile of the soil concentration in the SPKRSeg.

4.1.1.2.8 Birds and Mammals

Potential risks to birds and mammals were evaluated for both external exposures (i.e., potential toxicity from ingestion of abiotic and biotic media) as well as for internal exposures (i.e., potential toxicity from accumulation of COPECs within specific tissues such as blood, liver, and kidney). Each of these exposures is discussed in the following subsections.

4.1.1.1.8.1 External Exposures

Potential risks from external exposures were estimated by dividing the total exposure estimate (derived in Section 3.1.2) by the toxicity reference value corresponding to the Effects Concentration 20 or EC20 (developed in Section 3.2.1.1) for each representative species. Exposure and potential risks were estimated for the representative species and habitats which were selected previously (Section 2.5.3) for which chemical data were available in the database. The exposure and risk calculations are presented in Appendix C, Table C-4.1.1.1.8.1-1. The potential risks were considered high if the HQ was greater than 100 (Table 4.1.1.1.8.1-1) medium if the HQ was between 10 and 100 (Table 4.1.1.1.8.1-2), and low if the HQ was between 1 and 10 (Table 4.1.1.1.8.1-3).

what is the reference for this interpretation of HQ

Birds

Lead resulted in the highest estimated risks to birds. The most impacted areas were riparian and riverine habitats (Table 4.1.1.1.8.1-1). The birds that had high estimated risks included Swainson's thrush, song sparrow, spotted sandpiper, and American dipper.

Chemicals that resulted in estimated risks in the medium range (HQ 10-100) consisted of cadmium, lead, and zinc (Table 4.1.1.1.8.1-2). Cadmium had only a few risk estimates in this range and consisted of exeedances for song sparrow and spotted sandpiper. Lead concentrations resulted in exeedances of this magnitude for wood duck, mallard, lesser scaup, common goldeneye, common merganser, ruffed grouse, wild turkey, spotted sandpiper, common snipe, black tern, belted kingfisher, tree swallow, American dipper, Swainson's thrush, American robin, and song sparrow. Zinc resulted in increased risks to American kestrel, spotted sandpiper, black tern, tree swallow, Swainson's thrush, American robin and song sparrow.

Chemicals that resulted in estimated risks in the low range (HQ 1-10) consisted of arsenic, cadmium, copper, lead, mercury, and zinc (Table 4.1.1.8.1-3). There were a large number of exceedances in this range. As such, the representative species that had risks in this range are listed in Table **4.1.1.1.8.1-4** for each COPEC.

Mammals

The highest estimated risks to mammals were from zinc (Table 4.1.1.1.8.1-1). The most sensitive receptors were masked shrew and long-legged myotis.

Chemicals that resulted in estimated risks in the medium range (HQ 10-100) consisted of arsenic, mercury, and zinc (Table 4.1.1.1.8.1-2). Receptors that were sensitive to arsenic include the little brown myotis, muskrat, and vagrant shrew. The little brown myotis is the only mammalian receptor to have exceedences in this risk range for mercury. The receptors that had modeled exposures exceeding zinc concentrations include the deer mouse; little brown myotis; long-legged myotis; and masked, vagrant, and water shrews.

Chemicals that resulted in estimated risks in the low range (HQ 1-10) consisted of arsenic, cadmium, copper, lead, mercury, and zinc (Table 4.1.1.8.1-3). There were a large number of exceedances in this range, and the representative species that had risks in this ranges are listed in Table 4.1.1.1.8.1-4 for each COPEC.

4.1.1.1.8.2 Internal Exposures

Both measured and estimated concentrations of COPECs in target tissues (e.g., blood, liver and kidney) of birds and mammals were available for multiple locations and multiple species from within the Coeur d'Alene River basin. These data are summarized in Section 3.1.2.6.2. Ecological significance of these internal exposures was evaluated by comparison to target organ effects concentrations summarized in Section 3.2.1.1.8.2 and to distributions of COPECs in tissues of biota from other contaminated and uncontaminated locations. These comparisons are presented below.

4.1.1.1.8.2.1 Blood Lead in Birds

Blood lead concentrations were measured in nine species in the Coeur d'Alene River basin (tundra swans, Canada geese, mallard and wood ducks, osprey, American kestrels, bald eagles, northern harriers, and great horned owls). Blood lead concentrations were also estimated for five species (tundra swans, Canada geese, mallard and wood ducks, and American dippers).

Tundra Swans

All measured blood lead concentrations in tundra swans from the Coeur d'Alene River basin exceeded the 90th percentile for swans from regional reference areas and fell within concentration ranges diagnostic of clinical to severe clinical lead poisoning (Figure 4.1.1.1.8.2-1). Concentrations measured in moribund and live birds were comparable. Regardless of location or health status, median blood lead concentrations for swans from the Coeur d'Alene River basin were between 1 and 5 mg/kg wet weight (Figure 4.1.1.1.8.2-1). Blood lead concentrations estimated for tundra swans (based on lead in sediments) also consistently fell within the range diagnostic of severe clinical lead poisoning; median blood lead concentrations were between 1 and 4 mg/kg wet weight for 10 of 12 segment-habitat type combinations (Figure 4.1.1.1.8.2-2). Only for the lacustrine habitat within CSM Unit 3, segments LCDRSeg01 and LCDRSeg03 did median estimated blood lead concentrations fall below the severe clinical poisoning level.

The conclusion from these data is that lead presents a significant risk to both the health and survival of tundra swans throughout CSM unit 3.

Canada Geese

Although measured blood lead concentrations in Canada geese from the Coeur d'Alene River basin exceeded the 90th percentile for geese from regional reference areas, >90% of observations fell within the subclinical lead poisoning concentration range (Figure 4.1.1.1.8.2-3). In addition, although median concentrations in geese exceeded median concentrations in live tundra swans, all concentrations in geese were less than the 10th percentile concentration in moribund tundra swans. In contrast to measured concentrations, median estimated blood lead concentrations for all segments in CSM unit 3 fell within the range diagnostic of severe clinical lead poisoning; only within CSM unit 5 did median blood lead estimates fall below the severe clinical poisoning range (Figure 4.1.1.1.8.2-4).

The conclusion from these data is that lead presents a significant risk to both the health and potentially survival of Canada geese throughout CSM units 3 and 5.

Mallard Ducks

All measured blood lead concentrations in mallard ducks from the Coeur d'Alene River basin exceeded the 90th percentile for mallards from regional reference areas, and median concentrations fell within the clinical or severe clinical lead poisoning ranges (Figure 4.1.1.1.8.2-5). Median estimated blood lead concentrations for 5 of 6 segments in CSM unit 3 fell within the range diagnostic of severe clinical lead poisoning (Figure 4.1.1.1.8.2-6). The single estimate from CSM 2 fell within the subclinical lead poisoning range, while 50% of estimates within CSM unit 5 (i.e., the the 25-75% inter-quantile range) fell entirely within the clinical poisoning range (Figure 4.1.1.1.8.2-6).

The conclusion from these data is that lead presents a significant risk to both the health and survival of mallard ducks throughout CSM units 3 and 5. Within CSM unit 2, health but not survival is at risk.

Wood Ducks

Measured blood lead concentrations in wood ducks were highly variable. There was significant overlap between concentrations measured in wood ducks from within the Coeur d'Alene River basin and regional reference areas (Figure 4.1.1.1.8.2-7). However, median concentrations for wood ducks for 4 of 5 areas from the Coeur d'Alene River basin fell within the clinical or severe clinical lead poisoning ranges, and were comparable to blood lead concentrations observed in moribund swans. Median estimated blood lead concentrations for all 6 segments in CSM unit 3 fell within the range diagnostic of clinical to severe clinical lead poisoning (Figure 4.1.1.1.8.2-8).

The conclusion from these data is that lead presents a significant risk to both the health and survival of wood ducks throughout CSM units 3.

Osprey

Blood lead concentrations measured in osprey from the Coeur d'Alene River basin, although somewhat elevated compared to concentrations from regional reference areas, generally fell within the background range (Figure 4.1.1.1.8.2-9). Seventy-fifth percentile concentrations fell below the threshold for subclinical effects for all areas; the 90th percentile of blood lead distributions extended into the subclinical lead poisoning range for only two areas (CSM unit 3, segments 4 and 5). With the exception of a single observation from CSM unit 4, no blood lead observations in osprey were sufficiently high to indicate clinical lead poisoning.

The conclusion from these data is that lead presents a minimal risk to the health and no risk to survival of osprey in the Coeur d'Alene River basin.

American Kestrel

Blood lead concentrations measured in kestrels from the Coeur d'Alene River basin, although somewhat elevated compared to concentrations from regional reference areas, generally fell within the background to subclinical lead poisoning ranges (Figure 4.1.1.1.8.2-10). The 90th percentile of blood lead distributions extended into the clinical lead poisoning range for only one area in the Coeur d'Alene River basin (CSM unit 3, segment 2). The 90th percentile of blood lead from kestrels from the St. Joe basin also extended into the clinical lead poisoning range (Figure 4.1.1.1.8.2-10).

The conclusion from these data is that lead presents a minimal risk to the health and no risk to survival of American kestrels in the Coeur d'Alene River basin.

Bald Eagles

Blood lead concentrations measured in bald eagles from the Coeur d'Alene River basin, although elevated compared to concentrations from regional reference areas, fell entirely within the background range (Figure 4.1.1.1.8.2-10). The conclusion from these data is that lead does not present a risk ~~to the~~ health or survival of bald eagles in the Coeur d'Alene River basin.

Northern Harriers

Blood lead concentrations measured in harriers from the Coeur d'Alene River basin, although somewhat elevated compared to concentrations from regional reference areas, generally fell within the background to subclinical lead poisoning ranges (Figure 4.1.1.1.8.2-11). The 90th percentile of blood lead distributions extended into the subclinical lead poisoning range for only two areas in the Coeur d'Alene River basin (CSM unit 3, segments 3 and 6).

The conclusion from these data is that lead presents a minimal risk to the health and no risk to survival of northern harriers in the Coeur d'Alene River basin.

Great Horned Owls

Blood lead concentrations measured in great horned owls from the Coeur d'Alene River basin fell entirely within the background range (Figure 4.1.1.1.8.2-11). The conclusion from these data is that lead does not present a risk to the health or survival of great horned owls in the Coeur d'Alene River basin.

American Dippers

Blood-lead-based effect levels specific for dippers or other passerines were not available. However, because for blood-lead-based effect levels for waterfowl, falconiformes, and galliformes were comparable (see Table 3.2.1.1.8.2-2), effects levels for waterfowl were assumed to be representative.

Median estimated blood lead concentrations in dippers were all below the threshold for subclinical lead poisoning (Figure 4.1.1.1.8.2-12). Although maximum estimated blood lead concentrations were within the subclinical lead poisoning range for 4 of 5 areas in CSM unit 1, the threshold for clinical lead poisoning was not exceeded in any area (Figure 4.1.1.1.8.2-12).

The conclusion from these data is that lead presents a minimal risk to the health of dippers in CSM unit 1 but not to survival.

4.1.1.1.8.2.2 Liver Lead in Birds

Concentrations of lead in liver tissue were measured in nine species in the Coeur d'Alene River basin (tundra swans, Canada geese, mallard and wood ducks, American kestrels, bald eagles, northern harriers, great horned owls, American robins, and song sparrows). Liver lead concentrations were also estimated for five species (tundra swans, Canada geese, mallard and wood ducks, and American dippers).

Tundra Swans

Liver concentration data for tundra swans found dead or moribund were compared to waterfowl liver-effect levels from Pain (1996) and to liver lead distributions for swans diagnosed as lead-poisoned reported in Blus et al. (1989) and Honda et al. (1990). Lead concentrations in livers from swans from the Coeur d'Alene River basin were greatly elevated over the single observation from a reference location and were generally consistent with concentrations associated with lead poisoning (Figure 4.1.1.1.8.2-13). With the exception of the single observation from CSM Unit 3, segment 2 which was in the subclinical poisoning range, median liver lead concentrations from all areas either exceeded or were marginally below the severe clinical effects threshold.

Liver lead concentrations estimated for tundra swans were somewhat lower than measured concentrations; median blood lead concentrations were within the clinical lead poisoning range for 9 of 12 segment-habitat type combinations (Figure 4.1.1.1.8.2-14). Only for the lacustrine habitat within CSM Unit 3, segments LCDRSeg01 and LCDRSeg03, and palustrine habitat in CSM Unit 3, LCDRSeg05 did median estimated blood lead concentrations fall below the clinical poisoning level.

The conclusion from these data is that lead presents a significant risk to both the health and survival of tundra swans throughout CSM unit 3.

Canada Geese

Liver lead concentrations for Canada geese were available both for birds found dead and those collected live from within the Coeur d'Alene River basin. Concentrations of lead in livers of geese found dead, regardless of whether they had been diagnosed as lead-poisoned, were greatly elevated as compared to birds collected live (Figure 4.1.1.1.8.2-15). Median concentrations of dead geese were within the clinical poisoning range. Among geese collected live, liver lead concentrations were elevated over regional reference areas, but only within CSM Unit 3, segment 5 did the maximum liver lead concentration exceed the subclinical lead poisoning threshold. In contrast to measured concentrations, median estimated blood lead concentrations for 5 of 6 segments in CSM unit 3 fell within the range diagnostic of clinical lead poisoning; only within CSM unit 3, segment 5, and in CSM unit 5 were median blood lead estimates within the subclinical poisoning range (Figure 4.1.1.1.8.2-16).

The conclusion from these data is that lead presents a significant risk to health and potentially survival of Canada geese throughout CSM units 3 and 5.

Mallard Ducks

Concentrations of lead in livers of mallard ducks found dead in the Coeur d'Alene River basin were marginally higher than those collected live from the basin (Figure 4.1.1.1.8.2-17). Median lead concentrations for all groups fell within the subclinical to clinical lead poisoning ranges; with the exception of the upper portion of the distribution for mallards found dead but not diagnosed as lead poisoned, no birds were found or collected with liver concentrations that fell within the severe clinical poisoning range. Similar to measured concentrations, estimated liver lead concentrations were within the subclinical to clinical lead poisoning ranges for 6 of 8 areas (Figure 4.1.1.1.8.2-18). The single estimate from CSM 2 and the median from CSM unit 5 fell within the background range.

The conclusion from these data is that lead presents a significant risk to the health and a potential risk to the survival of mallard ducks throughout CSM unit 3. Within CSM unit 2, no risks are estimated.

Wood Ducks

Although all wood ducks found dead within the Coeur d'Alene River basin were diagnosed as not lead poisoned, median liver lead concentrations fell within the severe clinical poisoning range (Figure 4.1.1.1.8.2-19). Among wood ducks collected live, liver lead concentrations for birds from the basin greatly exceeded the single observation from a regional reference area, with median concentrations falling within the subclinical poisoning range. Median estimated blood lead concentrations for 5 of 6 segments in CSM unit 3 fell within the range diagnostic of subclinical lead poisoning; the median for CSM unit 3, segment 5 fell within the background range (Figure 4.1.1.1.8.2-20).

The conclusion from these data is that lead presents a significant risk to health and a potential risk to survival of wood ducks throughout CSM units 3.

Birds of Prey

Liver lead data were available for four bird of prey species within the Coeur d'Alene River basin: bald eagles, great horned owls, northern harriers, and American kestrels (Figure 4.1.1.1.8.2-21). These data were compared to liver lead data from captive raptors diagnosed as having been lead poisoned, data from wild sharp-shinned hawks collected in eastern North America, and the liver lead effects thresholds for raptors reported by Franson (1996). Concentrations of lead in livers of all bird of prey species from all locations within the Coeur d'Alene River basin were comparable to those measured in hawks from eastern North America, were within the background range, and were below minimal concentrations measured in livers of raptors diagnosed as lead poisoned (Figure 4.1.1.1.8.2-21).

The conclusion from these data is that lead does not present a significant risk to health or survival of birds of prey in the Coeur d'Alene River basin.

American Robins and Song Sparrows

Liver lead data for American robins and song sparrows were compared to liver lead data from captive starlings and other passerines experimentally lead-poisoned, to data from wild passerines collected from urban and rural areas in Illinois, and the liver lead effects thresholds for waterfowl reported by Pain (1996). The highest liver lead concentrations for both robins and sparrows were observed in CSM unit 3, segment 3, with 75th percentile concentrations falling in the clinical poisoning range for both species (Figure 4.1.1.1.8.2-22). Maximum concentrations for all other areas for robins did not exceed the subclinical poisoning range; maximum concentrations for sparrows exceeded the clinical poisoning threshold in 3 of 4 areas. Liver lead concentrations for both robins and sparrows were less than those observed in passerines experimentally poisoned with lead, were generally comparable to those in wild passerines from urban areas in Illinois, but generally greater than those from wild passerines from urban areas in Illinois (Figure 4.1.1.1.8.2-22).

The conclusion from these data is that lead presents a risk to health but not survival of American robins and sparrows in the Coeur d'Alene River basin.

American Dippers

Median estimated liver lead concentrations in dippers were all below the threshold for subclinical lead poisoning (Figure 4.1.1.1.8.2-23). Maximum estimated liver lead concentrations were within the clinical lead posioning range for 4 of 5 areas in CSM unit 1, with the maximum for Canyon Creek exceeding the threshold for clinical lead poisoning (Figure 4.1.1.1.8.2-23).

The conclusion from these data is that lead presents a risk to the health and potentially to survival of dippers in CSM unit 1.

4.1.1.1.8.2.3 Other Metals in Avian Liver or Kidney Tissue

Concentrations of arsenic, cadmium, copper, mercury, and zinc in liver or kidney tissue were measured in multiple avian species in the Coeur d'Alene River basin.

Arsenic

Concentrations of arsenic measured in livers of tundra swans, American robins, and song sparrows ranged from 0.05 to 0.8 mg/kg wet weight (Figure 4.1.1.1.8.2-24). Based on data from Stanley et al. (1994), 4.4 mg/kg (wet) arsenic in the liver is estimated to result in a 50 percent reduction in reproductive success among mallards consuming diets containing sodium arsenate for over 10 weeks.

The conclusion from these limited data is that arsenic does not present a risk to health or survival of tundra swans, American robins, or song sparrows in the Coeur d'Alene River basin.

Cadmium

Measured or estimated concentrations of cadmium in liver tissue from multiple bird species from multiple locations within the Coeur d'Alene River basin are summarized in Figures 4.1.1.1.8.2-25 through 4.1.1.5.2-27. Measured concentrations of cadmium in kidneys of individuals of three raptor species from the Coeur d'Alene River basin are summarized in Figure 4.1.1.1.8.2-28. Maximum concentrations of cadmium in the livers were less than 2 mg/kg wet weight for geese and mallards (Figure 4.1.1.1.8.2-25), less than 3 mg/kg wet weight for swans, robins, and sparrows (Figure 4.1.1.1.8.2-26), and less than 1 mg/kg wet weight for American dippers (Figure 4.1.1.1.8.2-27). Maximum concentrations of cadmium in the kidneys were less than 2 mg/kg dry weight for birds of prey (Figure 4.1.1.1.8.2-28)

Based on data from DiGiulio and Scanlon (1984), 261 mg/kg (wet) cadmium in the liver or 541 mg/kg (dry) in the kidney is estimated to result in a 50% weight loss among mallards consuming diets containing cadmium chloride for over ~42 days. Puls (1988) reports that 25 to 208 mg/kg wet weight cadmium in liver tissue is 'toxic 'to waterfowl (note: nature of toxicity is not defined). Furness (1996) suggests that 100 mg/kg in kidneys is a toxicity threshold in birds; concentrations below this level are not expected to result in any adverse effects.

Because measured or estimated concentrations of cadmium in avian liver or kidney tissues are all below the various effects thresholds, the conclusion from these data is that cadmium does not present a risk to health or survival of birds in the Coeur d'Alene River basin.

Copper

Maximum concentrations of copper measured in livers of tundra swans, American robins, song sparrows, great horned owls, northern harriers, and American kestrels from the Coeur d'Alene River basin did not exceed 50 mg/kg wet weight (Figure 4.1.1.1.8.2-29). This concentration is comparable to literature-derived reference swans and an order of magnitude lower than concentrations measured in swans suspected of having been copper-poisoned (Figure 4.1.1.1.8.2-29).

The conclusion from these data is that copper does not present a risk to health or survival of birds in the Coeur d'Alene River basin.

Mercury

Maximum concentrations of mercury measured in livers of tundra swans, American robins, song sparrows, great horned owls, northern harriers, and American kestrels from the Coeur d'Alene River basin did not exceed 0.6 mg/kg wet weight (Figure 4.1.1.1.8.2-30). This concentration is less than the lowest concentration (0.89 mg/kg wet weight) observed among mallards exposed to 0.5 mg/kg methyl mercury in their diet for 3 generations. Furthermore, zebra finches that died following consumption of diets containing methyl mercury for 76 days had mercury concentrations in their liver of 73 mg/kg wet weight (Scheuhammer 1988).

The conclusion from these data is that mercury does not present a risk to health or survival of birds in the Coeur d'Alene River basin.

Zinc

Measured concentrations of zinc in liver tissue from multiple bird species from multiple locations within the Coeur d'Alene River basin are summarized in Figures 4.1.1.1.8.2-31 through 4.1.1.5.2-34. Target organ toxicity data were limited to the definition of 200 to 700 mg/kg wet weight in the liver as being the 'toxic' range for poultry (Puls 1988).

Among tundra swans found dead in the Coeur d'Alene River basin, median and 75th percentile concentrations for swans diagnosed as lead poisoned or suspected to be lead poisoned exceeded the lower threshold for avian zinc toxicity, whereas the maximum zinc concentration in swans diagnosed as not lead poisoned was below the minimum threshold (Figure 4.1.1.1.8.2-31). Based on data from the reconnaissance study (Audet 1997), zinc concentrations in livers of swans from the Coeur d'Alene River basin greatly exceeded those for swans from the St. Joe. Furthermore, median and 25th percentile concentrations at 3 of 4 areas exceeded the minimum toxicity threshold (Figure 4.1.1.1.8.2-31).

Zinc concentrations in livers of Canada geese diagnosed as lead-poisoned exceeded the minimum toxicity threshold; concentrations in livers of geese diagnosed as not lead-poisoned or collected live did not exceed the toxicity threshold (Figure 4.1.1.1.8.2-32). Among mallards, regardless of whether mortality was diagnosed to be from lead mortality or if birds were collected live, concentrations of zinc in the liver did not exceed the toxicity threshold (Figure 4.1.1.1.8.2-33). Similar results were also obtained for American robins, song sparrows, and birds of prey (Figure 4.1.1.1.8.2-34).

The conclusion from these data is that zinc presents a risk to health or survival of tundra swans and to a lesser degree, Canada geese, in the Coeur d'Alene River basin, particularly in CSM unit 3. The correlation between zinc concentrations in liver exceeded toxicity thresholds and diagnoses of mortality due to lead poisoning suggests an interaction between the two metals. Available data do not indicate that zinc presents a risk to health or survival of mallards, American robins, song sparrows, or birds of prey in the Coeur d'Alene River basin.

4.1.1.1.8.2.4 Metals in Mammalian Liver or Kidney Tissue

Concentrations of arsenic, ~~cadmium~~, copper, mercury, lead, and zinc in liver or kidney tissue were measured in multiple mammalian species in the Coeur d'Alene River basin.

Arsenic

The limited data on arsenic concentrations in livers of mammals from the Coeur d'Alene River basin were compared to liver concentration data for rock squirrels from multiple uncontaminated areas in Utah (Sharma and Shupe 1977) and to the 10 mg/kg wet weight toxicity threshold for dogs, horses and sheep reported in Puls (1988; note that the nature of the toxicity is not defined). Concentrations of arsenic in beaver, deer mice and muskrats were all below the median concentrations observed in rock squirrels and below the 10 mg/kg toxicity threshold (Figure 4.1.1.1.8.2-35).

The conclusion from these data is that arsenic does not present a risk to health or survival of mammals in the Coeur d'Alene River basin.

Cadmium

Concentrations of cadmium were measured in kidneys of mink (Figure 4.1.1.1.8.2-36) and livers of muskrat (Figure 4.1.1.1.8.2-37). Concentrations in organs of both species were compared to concentrations measured at other locations in North America; kidney concentrations were also compared to the toxicity thresholds reported by Cooke and Johnson (1996). Cadmium concentrations in kidneys of mink from the Coeur d'Alene River basin were comparable to those reported elsewhere in North America and were also dramatically below the toxicity threshold of 350 mg/kg dry weight (Figure 4.1.1.1.8.2-36). Concentrations of cadmium in livers of muskrat for the Coeur d'Alene River basin varied from being within the range of concentrations from other locations in North America to somewhat exceeding these concentrations (Figure 4.1.1.1.8.2-37). Although a toxicity threshold concentration for the liver was not located in the literature, it is likely to be greater than the 350 mg/kg dry weight (100 mg/kg wet weight) reported by Cooke and Johnson (1996) for kidneys, the primary target organ for cadmium toxicity. Because the highest concentrations in muskrat livers from the Coeur d'Alene River basin were less that 1 mg/kg wet weight, two orders of magnitude below kidney effect level, it is unlikely that effects from cadmium would occur.

The conclusion from these data is that cadmium does not present a risk to health or survival of mink or muskrat in the Coeur d'Alene River basin.

Copper

Maximum concentrations of copper measured in the livers of beaver, meadow voles, *Peromyscus*, and muskrat were either less than or within the range of concentrations observed in organs of mammals from other locations in North America (Figure 4.1.1.1.8.2-38). In addition, all concentrations from the basin were below the concentration (68 mg/kg wet weight) that resulted in liver toxicity in 50% of rats exposed to copper sulfate for 13 weeks (Hebert et al. 1993).

The conclusion from these data is that copper does not present a risk to health or survival of mammals in the Coeur d'Alene River basin.

Mercury

Maximum concentrations of mercury measured in the livers of beaver, meadow voles, *Peromyscus*, and muskrat were either less than or within the range of concentrations observed in organs of mammals from other locations in North America (Figure 4.1.1.1.8.2-39). In addition, all concentrations from the basin were at least 2 orders of magnitude below the concentrations (>10 mg/kg wet weight) that resulted in mortality in mink consuming diets containing methyl mercury (Wobeser et al. 1986).

The conclusion from these data is that mercury does not present a risk to health or survival of mammals in the Coeur d'Alene River basin.

Lead

Measured concentrations of lead in livers from mink, muskrat, meadow voles, deer mice, and beaver from the Coeur d'Alene River basin and other locations in North America are summarized in Figures 4.1.1.1.8.2-40 through 4.1.1.1.8.2-43. Concentrations of lead in livers of mink from the basin generally exceeded those observed in other locations in North America (Figures 4.1.1.1.8.2-40). Additionally, all concentrations in livers of individual mink found dead in CSM unit 3 segment 5, and maximum concentrations in mink collected live from CSM unit 3 exceeded the toxicity threshold of 5 mg/kg wet weight reported in Ma (1996).

Concentrations of lead in livers of muskrat from the basin were equal to or greater than those observed in most other locations in North America (Figures 4.1.1.1.8.2-41). However, only at two locations (CSM unit 3 segment 6 and CSM unit 2) did measured concentrations exceed the mammalian toxicity threshold.

Concentrations of lead in livers of meadow voles from the basin were somewhat elevated relative to those observed in other locations in North America (Figures 4.1.1.1.8.2-42). In addition, the maximum concentrations in voles both found dead or collected from CSM unit 3 segment 4 exceeded the mammalian toxicity threshold.

Although concentrations of lead in livers of beaver from the basin were somewhat elevated in comparison of other locations, deer mice were not (Figure 4.1.1.1.8.2-43). It should be noted however, that two of the three sites used for comparison for deer mice represent lead contaminated sites. Concentrations are elevated in comparison to the trap and skeet reference location. Lead concentrations in beaver and deer mice from the basin however, did not exceed the mammalian toxicity threshold.

The conclusions from these data are that :

Lead presents a risk to health and survival of mink, particularly in CSM unit 3.

Lead presents an equivocal risk to health and survival of muskrats and meadow voles. The risk is considered equivocal because exceedences of the mammalian threshold were marginal and not consistent.

Lead does not present a risk to health and survival of beaver or deer mice.

Zinc

Concentrations of zinc in livers of muskrat (Figure 4.1.1.1.8.2-44), meadow voles, *Peromyscus*, and beaver (Figure 4.1.1.1.8.2-45) were generally comparable to those observed at other locations in North America. Further, maximum concentrations in livers of mammals from the Coeur d'Alene River basin were all substantially below the 128 mg/kg wet weight in liver that is estimated to result in 50% mortality of ferrets consuming diets containing zinc oxide for ~197 days (Straube et al. 1980).

The conclusions from these data are that zinc does not present a risk to health and survival of mammals in the Coeur d'Alene River basin.

4.1.1.2 Site-Specific Ambient Media Toxicity Tests

Site-specific toxicity testing using water from (or fish exposed in-situ) Canyon Creek, Segment05 and CSM Unit 2, Segments 1 and 2 indicated high toxicity to trout (Section 3.2.1.2). Other tests with metals added individually to water from the Little North Fork of the South Fork of the Coeur d'Alene River indicated toxicity of cadmium and zinc to trout that was similar to that predicted by the ambient water quality criteria. Toxicity of lead was less toxic than predicted by the ambient water quality criteria in those experiments (EVS 1996a, 1996b).

4.1.1.2.1 Fish [Section deleted]

4.1.1.2.2 Benthic Invertebrates [Section deleted]

4.1.1.2.3 Terrestrial Plants

Phytotoxicity bioassays conducted on soils from the Coeur d'Alene River basin have been summarized in Section 3.2.1.2.3. Early seedling and hybrid poplar toxicity tests were performed on soils from 26 and 19 locations in the basin, respectively. Because results from the hybrid poplar tests were comparable to those from the early seedling tests (Kapustka 1999), for simplicity, the risk characterization is based on these later tests.

Results from the bioassays on soils from each location were expressed as a categorical response variable ranging from non-phytotoxic to severely phytotoxic (Kapustka 1999). Definitions for each category were as follows:

- Non-phytotoxic – sample did not differ statistically significantly from control
- Mildly phytotoxic – sample differed statistically significantly from control but was >75% of control
- Moderately phytotoxic - sample differed statistically significantly from control and was >50 to 75% of control
- Highly phytotoxic - sample differed statistically significantly from control and was >25 to 50% of control
- Severely phytotoxic - sample differed statistically significantly from control and was <25% of control

All soil samples from the Coeur d'Alene River basin were found to be mildly to severely phytotoxic (Table 4.1.1.2.3-1). Of three locations in Canyon Creek, two were severely and one was highly phytotoxic. In Ninemile Creek, both locations tested were severely phytotoxic. In UpSFCDRSeg01, phytotoxicity was generally mild; however, moderate and high toxicity were measured at one location each (Table 4.1.1.2.3-1). Phytotoxicity at three locations tested in CSM 2 was moderate to mild. Finally, of 12 locations tested in CSM 3, severe toxicity was observed at 5, high toxicity at 3, and moderate or mild toxicity at two sites each.

The conclusion based on these analyses is that soils within the Coeur d'Alene River basin are phytotoxic, presenting risks to both health and survival of plants in the basin. The most severe toxicity and greatest risks to health and survival are present in Canyon and Ninemile Creeks in CSM 1. The lowest risks to plant health and survival are present in CSM 1 UpSFCDRSeg01 and CSM 2. Risks to plants in CSM 3 are variable, but generally high to severe.

4.1.1.2.4 Amphibians

Amphibian bioassays conducted using media from the Coeur d'Alene River basin are summarized in Section 3.2.1.4.2.1.

Results from Lefcort et al. (1998) indicate that exposure of spotted frog tadpoles to metals-contaminated sediments from the Coeur d'Alene River basin results in reduced growth, survival, and predator avoidance behavior. However, because the report described neither the specific locations from which sediment samples were obtained nor the metals concentrations in the sediments to which the tadpoles were exposed, more detailed integration of these results is problematic.

Howard et al. (date??) found that amphibian hatching success and overall survival decreased with increasing concentrations of metals in sediment.

Hatching success in samples with no metals was approximately 50%, whereas a 20% reduction in hatching success was observed in samples containing 6835 mg/kg lead, 4035 mg/kg zinc, and 30.5 mg/kg cadmium. Based on survival analyses, Howard et al. (date??) observed that the probability of death increased by 5.6% for every additional 1000 mg/kg increase in lead concentration. The instantaneous probability of death at the most contaminated site tested, 8570 mg/kg lead, was found to be 60.5% greater than the uncontaminated reference site.

Risks associated with lead, cadmium, and zinc concentrations that resulted in 20% reductions in hatching success were evaluated by overlaying these concentrations on the soil-sediment distributions presented in Section 2.3.2. Maximum lead concentrations in soil-sediment exceeded the 20% amphibian effect concentration for all areas except CSM unit 3 segment 1 and CSM unit 5 (Figure 4.1.1.2.4-1). The greatest risks to amphibians from lead is in CSM unit 1; the median lead concentration in UpSFCDRSeg01 and the 75th percentile concentrations in Canyon and Ninemile Creeks exceeded the threshold. Throughout CSM unit 3, 90th percentile lead concentrations were at or below the 20% effect threshold. In comparison to lead, risks to amphibians from zinc are more uniform throughout the basin, with maximum concentrations in soil-sediment exceeding the 20% effect threshold in all areas and the 90th percentile exceeding the threshold in 10 of 13 areas (Figure 4.1.1.2.4-2). For cadmium, maximum concentrations in soil-sediment exceeded the 20% effects threshold in all but one area (CSM 1 unit Pine Creek; Figure 4.1.1.2.4-3). The greatest risks from cadmium are in CSM unit 3; 75th percentiles exceeded the effect threshold for 5 of 6 areas.

The conclusion based on these analyses is that sediments within the Coeur d'Alene River basin present risks to both, survival, and reproduction of amphibians in the basin. Whereas lead presents the greatest risk in the upper basin (i.e. CSM unit 1), cadmium presents the greatest risk in the Lower Coeur d'Alene River basin (i.e., CSM unit 3). Risks from zinc are comparatively uniform throughout the basin.

4.1.1.2.5 Birds

Four studies (Connor et al. 1994, Day et al. 1998, Heinz et al. 1999, and Hoffman et al. 1999, 2000) were conducted in which northern bobwhite or various species of waterfowl were fed diets containing differing levels of contaminated sediment from the Coeur d'Alene River basin. Summaries of these studies are presented in Section 3.2.1.2.4.2. Although mortality was not observed for any species at any exposure level in any of the studies, toxic responses indicative of lead poisoning were observed in almost all exposures (Table 4.1.1.2.5-1). Aminolevulinic acid dehydratase (ALAD) levels were significantly depressed and protoporphyrin levels were significantly elevated at exposures as low as 103 mg/kg lead in the diet. Hemoglobin and hematocrit were significantly depressed at 642 and 700 mg/kg lead in diet (Table 4.1.1.2.5-1). Discounting direct ingestion of sediment, which has been shown to contribute significantly to exposure of waterfowl to lead in sediments (Beyer et al. 1999), waterfowl may receive lead exposures comparable to those from the toxicity studies simply by consuming aquatic plants from the basin. Mean concentrations of lead in aquatic plants measured in CSM units 3 and 5 all exceeded the minimum dietary concentration that resulted in hemotoxic effects (Table 2.3.1.4-2).

The conclusion based on these analyses is that ingestion of sediments and plants within the Coeur d'Alene River basin presents risks to the health of waterfowl in the basin.

need to say something regarding quantification

4.1.1.2.6 Mammals

Site-specific mammalian bioassays were limited to two studies, one in which bioavailability of lead in soil was evaluated in human volunteers, and the other consisting of an evaluation of the toxicity of forage contaminated by smelter emissions to horses. Both studies are summarized in Section 3.2.1.2.4.3.

Results of the study of lead bioavailability in humans (Maddaloni et al. 1998) indicate that food ingestion acts to inhibit gastrointestinal absorption of lead. As much as 26% of ingested lead was absorbed among volunteers who had fasted for 24 hrs prior to the test. In contrast, absorption was only 2.5% among subjects that consumed breakfast prior to the test. Risk-based conclusions cannot be made directly from the results of this study. However, the observed gastrointestinal bioavailability of lead may be used to qualify estimated risk to wildlife in which soil ingestion is estimated to be the driver.

The study by Burrows et al. (1982) indicates that consumption of feed containing 423 mg/kg lead and 10.8 mg/kg cadmium results in toxicosis and mortality in horses in 84 to 100 days. For comparison, mean concentrations of cadmium and lead measured in terrestrial plants in the Coeur d'Alene River basin exceeded these effects thresholds in 4 of 8 and 3 of 8 areas, respectively (Table 2.3.1.4-2). It is reasonable to assume that large herbivores resident in the basin, such as mule and white-tailed deer, may consume and potentially be adversely affected by high concentrations of lead and cadmium in forage. The conclusion from this study is that lead and cadmium present a risk to the health of large herbivores in the Coeur d'Alene River basin.

4.1.1.3 Site-Specific Biological Surveys

4.1.1.3.1 Fish

Site-specific surveys of fish populations indicate an absence of fish in Canyon Creek, Segments 2 and 5, and Ninemile Creek Segments 1, 2, and 4 indicating they are severely affected by metals and other stressors (Table 3.2.1.3-2). Other stream sections with reduced fish populations compared to reference streams included all the other assessment areas sampled except Beaver Creek and the Upper South Fork of the Coeur d'Alene River (Table 3.2.1.3-2).

4.1.1.3.2 Benthic Invertebrates

what is the basis for this cross-comparison?

Site-specific surveys of benthic invertebrates (Table 3.2.1.3-5) suggest that metals effects on benthic invertebrates are not as severe as the effects on fish, but because of the incompatibility of sampling methods used in various studies, taxa richness was the only metric that could be compared across studies.

4.1.2 Physical and Biological Risks

Some introductory text to help guide readers.

4.1.2.1 Riparian Vegetation

4.1.2.1.1 Vegetation Analysis

Data presented in Table F-3.1.1.2.2.10-5 in Appendix F show that vegetated cover types were dominant in all 23 of the reference area sampling locations in CSM Units 1 and 2. The bare ground cover type was dominant in 18 of 29 sampling locations in the CSM Units 1 and 2 assessment area, but vegetated cover types were dominant in all sampling locations in MidGradSeg03 and MidGradSeg04. Vegetated cover types were dominant in all sampling locations on the lower Coeur d'Alene River.

Species richness data provided in Tables F-3.1.1.2.2.10-1, -2, and -3 in Appendix F are summarized in Table 4.1.2.1.1-1. Herb, shrub, and tree species richness is high in the CSM Unit 1 and 2 reference area and relatively low in the CSM Unit 1 and 2 assessment area. Species richness was moderate to high in CSM Unit 3.

The frequency of species occurrence data provided in Tables F-3.1.1.2.2.10-1, -2, and -3 are summarized in Table 4.1.2.1.1-2 to show general trends across the reference and assessment areas. Herb species with greater than 20 percent frequency in any area, and shrub and tree species with greater than 10 percent frequency in any area, were included in Table 4.1.2.1.1-2. The most frequently observed herb and shrub species in the CSM Unit 1 and 2 reference area include reed canary grass (*Phalaris arundinacea*), cow parsnip (*Heracleum lanatum*), stream violet (*Viola glabella*), creeping bentgrass (*Agrostis stolonifera*), Dewey's sedge (*Carex deweyana*), common tansy (*Tanacetum vulgare*), ninebark (*Physocarpus malvaceus*), alder (*Alnus incana*), and snowberry (*Symphoricarpus albus*). The only frequently observed herb or shrub in the CSM Unit 1 and 2 assessment area was *A. stolonifera*. Although *A. stolonifera* and *P. arundinacea* were also frequently observed in sample locations in CSM Unit 3, other dominant species in CSM Unit 3 were different than those found in CSM Units 1 and 2, and included bulrush (*Scirpus cyperinus*), oxeye daisy (*Chrysanthemum leucanthemum*), hardhack (*Spiraea douglasii*), and marsh cinquefoil (*Potentilla palustris*).

The information presented thus far shows that the bare ground cover type is dominant in the CSM Units 1 and 2 assessment area while vegetated cover types are dominant in the CSM Unit 1 and 2 reference area and the CSM Unit 3 assessment area. Species richness is low in the CSM Unit 1 and 2 assessment area relative to the reference area. Species richness is moderate to high in the CSM Unit 3 assessment area.

Box plots showing the variation in vegetation characteristics for the assessment segments in CSM Units 1, 2, and 3 and the CSM Units 1 and 2 reference area are shown in Figure 4.1.2.1.1-1. Results of the Mann-Whitney test comparing vegetation characteristics between assessment segments and reference area for CSM Units 1 and 2 are shown in Table 4.1.2.1.1-3. Results are discussed in the following sections.

4.1.2.1.1.1 CSM Unit 1

<u>Canyon Creek</u>

The condition of the riparian vegetation decreases along Canyon Creek from the headwaters to the confluence with the South Fork Coeur d'Alene River at Wallace. The upper segments of Canyon Creek (CCSeg01 and CCSeg02) have relatively intact riparian vegetation with high habitat complexity. ~~The lower portion of Canyon Cr~~eek (CCSeg04 and CCSeg05) has been heavily impacted by mining and urban development.

Canyon Creek is not an urban development, Any urban development is overwhelmed by the mining impacts

Habitat restoration work was conducted by the Silver Valley Trustees in the 1990s along most of the lower portion of Canyon Creek (CCSeg05). The restoration work included attempts to re-establish native vegetation in the riparian zone. Field observation following restoration showed that high flows have impacted many of the constructed habitat features and survival of plants is low (Heinle 1999). Wesche (1999) confirmed these observations by concluding that stream bank vegetation quality was rated as poor to marginal during a 1999 habitat survey.

Riparian vegetation line transect data were not available for CCSeg01. However, this segment lies above most of the mining-related activity in the Canyon Creek subbasin and has not been significantly modified by road construction or development. The November 1999 field visit found relatively intact riparian vegetation in this segment (Figure 4.1.2.3-5). Therefore, the condition of the riparian vegetation in CCSeg01 is rated as not degraded.

Riparian vegetation line transect data were not available for CCSeg02, but this segment lies above most of mining-related activities. The condition of the riparian vegetation, as observed during the November 1999 field visit, was variable (Figures 4.1.2.3-6 through 4.1.2.3-8). Therefore, the riparian vegetation in CCSeg02 was not rated.

Riparian vegetation line transect data were not available for CCSeg03. The modified BLM vegetative cover map (Stratus 2000b) shows that 32 percent of the floodplain in CCSeg03 is covered by bare ground. The condition of riparian vegetation could not be rated in this segment due to the lack of information.

Six riparian vegetation sampling sites were located in CCSeg05 just south of the boundary with CCSeg04. These six sampling sites were used to represent the riparian vegetation condition for CCSeg05 as well as CCSeg04. This extrapolation is justified for the following reasons:

- CCSeg04 and CCSeg05 occur downgradient of Burke and have received similar levels of mining and non-mining related impacts. Since the six sampling sites ~~occur near the boundary between CCSeg04~~ and CCSeg05, the average riparian vegetation condition for these samples is assumed to be representative of both segments.

what is meant by this?

- The percent bare ground estimated from the modified BLM vegetative cover map for the two segments is similar (93 percent bare ground for CCSeg04 and 95 percent bare ground for CCSeg05) suggesting a similar riparian vegetation status, namely low diversity and abundance.

- Experts familiar with the ecology of Canyon Creek believe that the riparian vegetation in CCSeg04 and CCSeg05 is composed of riparian vegetation of similar diversity and abundance (Le Jeune 2000).

The modified BLM vegetative cover map (Stratus 2000b) shows that 96 percent of the floodplain in CCSeg04 consists of bare ground. Furthermore, Wesche (1999) found the bank vegetation and vegetated zone width for the Canyon Creek reach extending from Burke to Wallace were ranked from poor to marginal. The November 1999 field visit showed that this segment of Canyon Creek is extensively channelized and little floodplain and riparian area remains (Figure 4.1.2.3-6). The condition of riparian vegetation in CCSeg04 is rated as degraded.

CCSeg05 has relatively low herb, shrub, and tree species diversity and cover relative to the CSM Unit 1 and 2 reference area (Figure 4.1.2.1.1-1). These observations are confirmed by the Mann-Whitney test, which showed herb and shrub diversity and cover were significantly lower than the reference area (Table 4.1.2.1.1-3). Furthermore, the modified BLM vegetative cover map shows that 96 percent of the floodplain in CCSeg05 consists of bare ground. Wesche (1999) found the bank vegetation and vegetated zone width for the Canyon Creek reach extending from Burke to Wallace were ranked from poor to marginal. The November 1999 field visit showed that this segment of Canyon Creek is extensively channelized and little floodplain and riparian area remains (Figures 4.1.2.3-10 through 4.1.2.3-12). The condition of riparian vegetation in CCSeg05 is rated as degraded.

not on a par

Ninemile Creek

The condition of the riparian vegetation decreases along Ninemile Creek from the headwaters to the confluence with the South Fork Coeur d'Alene River at Wallace. The upper segments of Ninemile Creek (NMSeg03 and presumably NMSeg01) have relatively intact riparian vegetation with high habitat complexity. The lower portions ~~of the East~~ Fork and main stem Ninemile Creek (NMSeg02 and NMSeg04) have been heavily impacted by mining and urban development.

Habitat restoration work was conducted by the Silver Valley Trustees in the 1990s along most of NMSeg02 and NMSeg04. The restoration work included attempts to re-establish native vegetation in the riparian zone. Field observation following restoration showed that high flows have impacted many of the constructed habitat features and survival of plants is low (Heinle 1999). Wesche (1999) confirmed these observations by concluding that stream bank vegetation quality was rated as poor to marginal during a 1999 habitat survey.

NMSeg02 has low herb, shrub, and tree species richness and cover relative to the CSM Unit 1 and 2 reference area (Figure 4.1.2.1.1-1). These observations are confirmed by the Mann-Whitney test, which showed herb and shrub diversity and cover were significantly lower than the reference area (Table 4.1.2.1.1-3). The modified BLM vegetative cover map shows that

72 percent of the floodplain in NMSeg02 consists of bare ground. Wesche (1999) found the bank vegetation and vegetated zone width for the Ninemile Creek reach extending from the Interstate Mine to Wallace were ranked as marginal. The condition of riparian vegetation in NMSeg02 is rated as degraded.

Five riparian vegetation sampling sites were located in NMSeg02 just north of the boundary with NMSeg04. These five sampling sites were used to represent the riparian vegetation condition for NMSeg02 and also NMSeg04. This extrapolation is justified for the following reasons:

- The sampling sites occur near the border between NMSeg02 and NMSeg04 and the stream and bank habitat for both segments was rated as similar by Wesche (1999).
- The percent bare ground estimated from the modified BLM vegetative cover map for the two segments is similar (72 percent bare ground for NMSeg02 and 74 percent bare ground for NMSeg04) suggesting a similar riparian vegetation status, namely low diversity and abundance.
- Experts familiar with the ecology of Ninemile Creek believe that the riparian vegetation diversity and abundance in NMSeg02 and NMSeg04 is in similar condition (LeJeune 2000).

The modified BLM vegetative cover map (Stratus 2000b) shows that 74 percent of the floodplain in NMSeg04 consists of bare ground. Wesche (1999) found the bank vegetation and vegetated zone width for the Ninemile Creek reach extending from the Interstate Mine to Wallace were ranked as marginal. The condition of riparian vegetation in CCSeg04 is rated as degraded.

Pine Creek

The Pine Creek Watershed has been subject to extensive mining activity along the East Fork and main stem (PineCrkSeg01 and PineCrkSeg03, respectively). West Fork Pine Creek (PineCrkSeg02) has had relatively little mining activity. The floodplain of PineCrkSeg01 and PineCrkSeg03 has been impacted by releases of mining-related hazardous substances and extensive physical alteration. PineCrkSeg01 has been the subject of recent intensive habitat restoration by the BLM. PineCrkSeg03 was extensively modified by the U.S. Army Corps of Engineers for flood control.

The only information available on riparian vegetation condition along PineCrkSeg01 was the modified BLM vegetative cover map (Stratus 2000b), which showed that only 3 percent of the floodplain was classified as bare ground. The BLM has recently implemented a stream restoration program for this segment that included hydrologic modifications and re-establishment of riparian vegetation. Information was insufficient to rate the condition of the riparian vegetation in PineCrkSeg01.

The only information available on riparian vegetation condition along PineCrkSeg03 was the modified BLM vegetative cover map (Stratus 2000b), which showed that only 2 percent of the floodplain was classified as bare ground. This information was insufficient to rate the condition of the riparian vegetation in PineCrkSeg03.

Moon Creek

Moon Creek has been subject to mining-related activities and riparian areas and floodplains in the watershed have been impacted by releases of mining-related hazardous substances. The modified BLM vegetative cover map (Stratus 2000b) showed that none of the floodplain in MoonCrkSeg02 was classified as bare ground. This information was insufficient to rate the riparian vegetation condition in MoonCrkSeg02.

Upper South Fork Coeur d'Alene River

The upper South Fork Coeur d'Alene River contains a single segment (UpperSFCDRSeg01), which extends from the headwaters of the South Fork Coeur d'Alene River (which is subject to relatively limited mining and development activities) to Wallace (where impacts from mining and urban development are significant). The South Fork parallels I-90 and is channelized through most of the lower portion of UpperSFCDRSeg01.

Riparian vegetation data were not collected from UpperSFCDRSeg01 as part of the NRDA (Hagler Bailly 1995). The modified BLM vegetative cover map (Stratus 2000b) showed that 36 percent of the floodplain in the lower half of this segment was classified as bare ground. Wesche (1999) concluded that the bank vegetation and vegetated zone width were rated as suboptimal for the reach extending upstream of the Golconda Mine to Shoshone Park. The November 1999 field visit by URS Greiner ecologists found that the riparian vegetation condition generally declined moving downstream from Idaho Department of Fish and Game hatchery facility at Shoshone Park to the Golconda Mine site (Figures 4.1.2.3-1 through 4.1.2.3-4). Because of the high degree of variability in the condition of the riparian vegetation among stream reaches, the condition of the riparian vegetation was not determined for UpperSFCDRSeg01.

4.1.2.1.1.2 CSM Unit 2

The condition of the riparian vegetation was highly variable within CSM Unit 2. The midgradient segments of the South Fork Coeur d'Alene River (MidGradSeg01 and MidGradSeg02) have been heavily impacted by mining and urban development. The lower portion of the North Fork Coeur d'Alene River (MidGradSeg03) has had much less impact from mining and urban development than the midgradient segments of the South Fork. The upper portion of the Coeur d'Alene River (MidGradSeg04) has been impacted by mining-related hazardous substances that have migrated down the South Fork, but impacts to riparian vegetation quality have not been overt.

In MidgradSeg01, results of the line transect evaluation show that the herb, shrub, and tree species richness and cover appear relatively low and bare ground relatively high compared to the reference area (Figure 4.1.2.1.1-1). These qualitative observations are confirmed by the Mann-Whitney test, which shows that herb and shrub diversity and cover were significantly lower and bare ground significantly higher than the reference area (Table 4.1.2.1.1-3). The modified BLM vegetative cover map (Stratus 2000b) showed that only 9 percent of the floodplain in MidGradSeg01 was classified as bare ground. Wesche (1999) concluded that the bank vegetation and vegetated zone width were rated as poor throughout this segment. The inconsistency of the BLM data to the line transect and Wesche data cannot be readily explained. Based upon available data, the riparian vegetation in MidGradSeg01 was rated as degraded.

Most vegetative characteristics for MidGradSeg03, with the exception of tree diversity and cover, appear to overlap the range of values present in the CSM Unit 1 and 2 reference area (Figure 4.1.2.1.1-1). These qualitative observations are confirmed by the Mann-Whitney test, which shows that statistically significant differences are limited to herb and shrub species number (Table 4.1.2.1.1-3). The riparian vegetation sampling sites in MidGradSeg03 are located on the lower North Fork Coeur d'Alene River below the confluence with the Little North Fork (Figure 3.1.1.2.2.10-1) and have received considerably less impact from mining activities. The riparian vegetation in MidGradSeg03 was rated as not degraded.

Most vegetative characteristics for MidGradSeg04, with the exception of herb and tree diversity and tree cover, appear to overlap the range of values present in the CSM Unit 1 and 2 reference area (Figure 4.1.2.1.1-1). These qualitative observations are confirmed by the Mann-Whitney test, which shows that statistically significant differences are limited to the number of herb species (Table 4.1.2.1.1-3). The modified BLM vegetative cover map (Stratus 2000b) showed that only 33 percent of the floodplain in this segment was classified as bare ground. Wesche (1999) found that percent bank vegetative cover ranged from less than 10 percent to less than 50 percent for 12 sampling sites within this segment (Table F-3.1.1.2.2.1-2 in Appendix F). The riparian vegetation sampling sites in MidGradSeg04 are located below the confluence of the North and South Forks of the Coeur d'Alene River and have received considerably less direct impact from mining activities. The riparian vegetation in MidGradSeg04 was rated as not degraded.

4.1.2.1.1.3 CSM Unit 3

laughable comparisons

The condition of the riparian vegetation in CSM Unit 3 appears high. There is considerably less urban development in CSM Unit 3 than in CSM Units 1 and 2. Agriculture is practiced on roughly ~~10,000 acres within the floodplain. In addition,~~ the hydrology of the lower Coeur d'Alene River and its floodplain has been highly modified through the creation of Post Falls dam and diking, channelization, and shoreline development. These alterations have disrupted the natural meander patterns of the river and fragmented the hydraulic connectivity between the river, lateral lakes, and wetlands.

Herb cover and species richness values appear high, and bare ground values appear low in all segments in CSM Unit 3, while shrub cover and species richness are highest in LCDRSeg01, LCDRSeg02, and LCDRSeg04 (Figure 4.1.2.1.1-1). Since reference area data were not available for CSM Unit 3, definitive conclusions on the condition of the riparian vegetation based upon the line transect data (Hagler Bailly 1995) could not be made. Figure 2.2.2.2-1 shows the typical riparian vegetation condition for the lower Coeur d'Alene River floodplain as observed during the November 1999 site visit. Wesche (1999) observed that stream bank erosion occurred along 33 percent of the total length of the Coeur d'Alene River from the I-90 bridge at Cataldo downstream to Coeur d'Alene Lake. Wesche visually estimated the percent vegetation cover at

100 sampling sites on the Coeur d'Alene River that were identified as having eroding banks. Data from Wesche's habitat survey are presented in Table F-3.1.1.2.2.1-2 in Appendix F and the stream bank vegetation cover data are summarized in Table 4.1.2.1.1-4. Bank vegetation cover was 50 percent or less in 98 of 100 sampling sites, but these data are difficult to interpret because conditions for suitable reference areas were not presented. The condition of bank vegetation reported by Wesche (1999) is not directly comparable to the vegetation data collected under the NRDA (Hagler Bailly 1995) because the sampling sites for the riparian resources injury assessment were located in the floodplain and generally removed from the bank of the Coeur d'Alene River (Figure 3.1.1.2.2.10-1). The condition of riparian vegetation did not appear degraded during the November 1999 field visit.

Although no definitive conclusion can be made based on this analysis, the riparian vegetation occurring in the floodplain in CSM Unit 3 does not appear to be degraded. This conclusion is consistent with results of the NRDA riparian resources evaluations (Hagler Bailly 1995; Stratus 1999; LeJeune and Cacela 1999).

4.1.2.1.2 Comparison of Riparian Vegetation and Soil Characteristics

Box plots showing the variation in soil characteristic for all assessment segments and the CSM Units 1 and 2 reference area are shown in Figure 4.1.2.1.2-1. As described in Section 3.2.2.10.1, only data from CSM Units 1 and 2 were used to compare the vegetation and soil characteristics. Results of Mann-Whitney tests comparing soil characteristics between the assessment segments and the reference area for CSM Units 1 and 2 are shown in Table 4.1.2.1.2-1 and the primary trends are as follows:

- Arsenic and other metals concentrations in CCSeg05, NMSeg02, MidGradSeg01, and MidGradSeg04 are significantly different from the reference area.
- Soil characteristics for MidGradSeg03, with the exception of nitrate, are not significantly different from the reference area.
- Soil texture characteristics in the assessment segments are generally not different from the reference area.
- There is no consistent trend in the relationships between assessment and reference values for pH and organic matter.
- Nitrate concentration in all assessment segments is significantly different from the reference area.

Correlation and regression analyses were performed on the vegetative and soil characteristics for sampling locations in CSM Units 1 and 2. Data from the lateral lakes area (CSM Unit 3) were excluded from this analysis because results presented in Section 4.1.2.1.1 did not show that the riparian vegetation in that area was degraded.

The following significant patterns are seen in the correlation matrix (Table 4.1.2.1.2-2):

- Correlation coefficients are statistically significant for virtually all comparisons except for pH, which was insignificantly correlated with all vegetative characteristics and many soil characteristics.
- Herb, shrub, and tree cover and species richness were positively correlated with one another and negatively correlated with bare ground.
- Herb, shrub, and tree cover and species richness were negatively correlated with arsenic and the concentrations of all metals analyzed; arsenic and metals concentrations were positively correlated with bare ground.
- Herb, shrub, and tree cover and species richness were negatively correlated with percent sand and positively correlated with percent clay and silt; bare ground was positively correlated with percent sand and negatively correlated with percent clay and silt.
- Herb, shrub, and tree cover and species richness were positively correlated with organic matter and negatively correlated with nitrate; bare ground was negatively correlated with organic matter and positively correlated with nitrate.
- Arsenic and metals concentrations were positively correlated with one another.
- Arsenic and metals concentrations were positively correlated with percent sand and negatively correlated with percent silt and clay.
- Arsenic and metals concentrations were negatively correlated with organic matter and positively correlated with nitrate.
- Percent sand was negatively correlated with percent clay, silt, and organic matter and positively correlated with nitrate; percent silt and clay were positively correlated with organic matter and negatively correlated with nitrate.
- Nitrate and organic matter were negatively correlated.

Many of the relationships shown in Table 4.1.2.1.2-2 are intuitive (e.g., as cover and species richness increase, so does the percent organic matter). One relationship that seems counterintuitive is that of nitrate to all the vegetative and many soil characteristics. Generally, an increase in soil nitrate is equated with an increase in vegetative characteristics, soil organic matter, and finer textured soil. The observed relationships of nitrate with vegetative and soil characteristics cannot be readily explained.

The results of the correlation analysis show a high degree of multicollinearity between soil characteristics (i.e., the values of the measured variables are not truly independent of each other). For example, soil metals concentrations are positively correlated with percent sand. Mulitcollinearity of independent variables can affect results of the multiple regression analysis by making it difficult to detect significant regression coefficients and increasing the standard error of the regression coefficient, thus decreasing the accuracy of the predicted values of the dependent variable (Johnson and Wichern 1982).

Results of the forward stepwise multiple linear regression analysis are summarized in Table 4.1.2.1.2-3. The regression equations for all the vegetative characteristics were statistically significant and accounted for between 26 and 82 percent of the variability in the dependent variables (i.e., vegetative characteristics). The greatest amount of variability was accounted for in the regression equations for bare ground (82 percent) and herb species richness (72 percent). Soil characteristics accounted for the lowest proportion of the variability for the tree cover and species richness characteristics. This is probably associated with the low cover and richness of tree species in assessment and reference areas.

The most commonly retained independent variables in the regression equations were lead (retained in six of the seven regressions), nitrate (four of seven) and organic matter (four of seven). Arsenic, cadmium, iron, manganese, zinc, and pH did not contribute significantly to any regression equations for any vegetative characteristic.

To aid in interpreting the results of the correlation and regression analysis, scatterplots were created for those independent variables that contributed significantly to the regression equations. The scatterplots used the untransformed data to make interpretation easier. Scatterplots for herb species richness versus soil lead concentration and organic matter, and bare ground versus soil lead concentration and organic matter, are shown in Figure 4.1.2.1.2-2 to illustrate the relationships. The scatterplots show that herb species richness and bare ground vary greatly among sites in relation to soil lead concentrations and soil organic matter percent. However, there appears to be a weak but statistically significant trend of increasing herb species richness with decreasing soil lead and increasing soil organic matter. In addition, increases in bare ground are associated with increasing soil lead and decreasing soil organic matter. Similar trends are found in scatterplots for many other comparisons of vegetative and soil characteristics.

4.1.2.2 Biological Measures [Section deleted]

4.1.2.3 Bank Stability

Risks to aquatic receptors in CSM Units 1 and 2 from bank instability are presented below. This risk estimation section is organized hierarchically by CSM unit, watershed or drainage, and segment.

4.1.2.3.1 Upper South Fork Coeur d'Alene River—UpperSFCDRSeg01

UpperSFCDRSeg01 encompasses the headwaters areas of the South Fork Coeur d'Alene River, which have been subject to relatively limited mining-related activity, and the beginning of evident mining-related impacts to the floodplain and riparian zone in the downstream areas of the segment. In addition to mining-related impacts, the central and downstream portions of the South Fork Coeur d'Alene River in this segment have been extensively modified for highway construction, secondary roads, and urban development. These influences have had an artificial influence on bank stability. Therefore, bank stability conditions in this segment vary from natural dynamic stability, to areas of instability from impacts of mining-related and other influences, to areas of artificial stability from channelization, as demonstrated in Figures 4.1.2.3-1 through 4.1.2.3-4.

Bank stability data, the corresponding estimate of bank stability, and risk estimation for aquatic receptors are presented in Table 4.1.2.3-1.

4.1.2.3.2 Canyon Creek

Bank stability conditions in Canyon Creek vary considerably from the headwaters segments to the mouth of the system in the town of Wallace. The headwaters portions of the watershed are relatively undisturbed, with intact and well-vegetated ~~riparian zones and a high level of bank~~ stability. Canyon Creek has been extensively channelized in the central portion of the watershed to protect roads, residences, and mining~~-related facilities.~~ In the lower ~~portion of~~ the watershed, there has been extensive modification of the riparian zone and floodplain due to historic mining-related impacts, recovery of mine tailings, and ongoing remediation activities. Changes in bank stability conditions along Canyon Creek are demonstrated in Figures 4.1.2.3-5 through 4.1.2.3-10.

should not lose sight of mining/milling that have overwhelmed basin

CCSeg01

Surveys of habitat conditions in CCSeg01 have not been conducted and no bank stability data are available. However, this segment lies above most of the mining-related activity in the Canyon Creek subbasin and upstream of CCSeg02 where available data indicate no risk from mining-related influences on bank stability, suggesting that conditions in this segment will rate high. In addition, CCSeg02 is influenced by channelization from road construction and development, where most of the stream channel in CCSeg01 has not been significantly modified and has lush riparian vegetation. This further suggests that bank stability conditions in this segment are high overall, posing no risk to aquatic receptors.

This assessment is supported by habitat conditions observed during a field visit in November 1999. As shown in Figure 4.1.2.3-4, bank stability conditions in a representative stream reach are comparable to reference conditions.

CCSeg02

Bank stability scores by data category, corresponding estimates of overall bank stability, and associated level of risk to aquatic receptors in CCSeg01 are shown in Table 4.1.2.3-2. Bank stability scores in this segment are high overall, resulting in a determination of no risk to aquatic receptors in this segment.

Unlike CCSeg01, bank stability in CCSeg02 is influenced by channelization for road construction and development, which limits other aspects of habitat quality. The lower reach of the segment enters a concrete culvert approximately 0.5 miles long at Burke.

CCSeg03

No surveys of habitat conditions in CCSeg03, Gorge Gulch, have been identified and data on bank stability are not available. The Bureau of Land Management (BLM) has identified floodplain and riparian areas impacted by mining activities over approximately half the main stem channel of Gorge Gulch (BLM 1998). Risks from bank instability cannot be characterized in this segment (BLM 1998).

CCSeg04

No recent surveys of habitat conditions in CCSeg04 have been identified and data on bank stability are not available. The BLM has identified riparian and floodplain habitats along the entire length of main stem channel in this segment as impacted by mining-related activities (BLM 1998). This segment of Canyon Creek is extensively channelized, little floodplain and riparian area remains, and bank stability is artificially high (Figure 4.1.2.3-6).

Due to the paucity of habitat data in this segment, risk to aquatic receptors from bank instability associated with mining-related releases of hazardous waste is not rated. Because of the highly channelized conditions the risk to aquatic receptors from bank instability is presumed to be low. However, riverine habitat conditions in this segment overall are poor due to the extent of habitat modification.

CCSeg05

Data on bank stability in CCSeg05 are shown in Table 4.1.2.3-3. In general, bank stability ratings for the survey locations score in marginal to sub-optimal ranges, resulting in a rating of low risk for this segment. It is important to note however, that much of the riparian zone soil in this segment has been removed from the banks and floodplains, and the streambanks are composed primarily of large cobbles and boulders that are immobile except under high flow conditions. Therefore, the bank stability rating does not fully capture the degree of ecological degradation present in this segment. Typical riparian zone and streambank conditions in CCSeg05, demonstrating the lack of erodable materials present, are shown in Figure 4.1.2.3-7.

4.1.2.3.3 Ninemile Creek

As with Canyon Creek, bank stability conditions in Ninemile Creek vary considerably from the headwaters segments to the mouth of the system in the town of Wallace. The headwaters portions of the watershed are relatively undisturbed, with intact and well-vegetated riparian zones and a high level of bank stability. Ninemile Creek has been extensively channelized in the central portion of the watershed to protect roads, residences, and mining-related facilities. In the lower portion of the watershed, there has been extensive modification of the riparian zone and floodplain as a result of historic mining-related impacts, recovery of mine tailings, and ongoing remediation activities.

NMSeg01

Data on bank stability in NMSeg01 are limited to one BURP survey location, as shown in Table 4.1.2.3-4. Based on these data, bank stability conditions in this segment are high, corresponding to a rating of no risk to aquatic receptors.

NMSeg02

Data on bank stability conditions in NMSeg02 are shown in Table 4.1.2.3-5. Unstable banks are present along approximately 45 percent of the segment length, which corresponds to a rating of moderate risk to aquatic receptors.

NMSeg03

No data on bank stability conditions are available for this segment. There are relatively few mining-related impacts in this segment of the Ninemile Creek watershed compared to other segments. Fine materials aggrading the stream channel are visible, suggesting that bank instability is present in some areas in this segment.

NMSeg04

Data for bank stability in NMSeg04 are presented in Table 4.1.2.3-6. As shown, the data taken at the SRI and RBP sampling locations conflict with the rating of lower bank stability assigned to the BURP sampling location. Assuming approximately average conditions between these survey locations along the entire segment length, the corresponding bank stability rating is estimated at 60 percent, resulting in a rating of moderate risk from bank instability in this segment. As with CCSeg05, the floodplain and riparian zone in this segment have been subject to extensive impacts from mining-related activities, resulting in a lack of erosive materials in the streambanks and floodplains.

4.1.2.3.4 Moon Creek

Moon Creek has been subject to mining-related activities and riparian areas and floodplains in the watershed have been impacted by releases of mining-related substances. Habitat data for the Moon Creek watershed reflect the impacts of mining-related and other activities on bank stability.

MoonCrkSeg01

Bank stability data for MoonCrkSeg01 are shown in Table 4.1.2.3-7. Bank stability conditions at survey locations indicate a low level of bank instability in this segment, with scores corresponding to a rating of low risk to aquatic receptors.

MoonCrkSeg02

Bank stability data for MoonCrkSeg02 are shown in Table 4.1.2.3-8. Bank stability conditions at survey locations indicate a generally low level of bank instability in this segment, corresponding to a rating of no risk to aquatic receptors.

4.1.2.3.5 Big Creek

The Big Creek watershed has had relatively little mining activity in comparison to other watersheds in the South Fork Coeur d'Alene River basin. The upstream segments of the watershed have been the subject of some historic exploration, but no extensive mining activities took place in these areas. In addition, road densities in the upstream segments of Big Creek are the lowest of all CSM segments in the basin. The downstream segment of Big Creek has been subject to more extensive mining-related impacts in conjunction with the Sunshine Mine and Mill Complex. Releases of mining-related substances have resulted in impacts to floodplain and riparian areas in the lower reaches of Big Creek.

BigCrkSeg01

Bank stability data for BigCrkSeg01 are shown in Table 4.1.2.3.5-1. Bank stability ratings vary between the SRI and RBP locations, and the BURP survey locations. An average bank stability rating of 85 percent has been assigned to this segment. It is important to note that the survey locations are in the most downstream portion of the segment, near forest roads that parallel the stream channel and that terminate a short distance upstream; the upstream areas of the segment are relatively undisturbed. This suggests that the survey locations are representative of worst-case conditions in the segment.

BigCrkSeg02

No data on bank stability were available for BigCrkSeg02, East Fork Big Creek. However, this segment has the lowest road density of any CSM segment in the Coeur d'Alene River basin (1.45 miles/square mile), and little historic mining activity. Based on the conditions present in adjacent segment BigCrkSeg01 and the lack of historic disturbance, this segment is assigned a rating of no risk from bank instability by best professional judgment.

BigCrkSeg03

As with BigCrkSeg02, no data on bank stability are available for BigCrkSeg03, West Fork Big Creek. Similar to BigCrkSeg02, road densities in this segment are low (1.48 miles/square mile) and there is a lack of large-scale historic or present mining activity. Therefore this segment is assigned a rating of no risk to aquatic receptors from bank instability, based on best professional judgment.

BigCrkSeg04

Bank stability data for BigCrkSeg04 are shown in Table 4.1.2.3.5-2. In general, habitat data indicate a low but present level of bank instability, constituting a low level of risk to aquatic receptors.

4.1.2.3.6 Pine Creek

The Pine Creek watershed has been subject to extensive mining activity in East Fork Pine Creek (PineCrkSeg01) and along the main stem in the lower reaches of the watershed (PineCrkSeg03). West Fork Pine Creek (PineCrkSeg02) has been subject to little mining-related activity, although other anthropogenic impacts are present. The stream banks and floodplain areas of PineCrkSeg01 and PineCrkSeg03 have been impacted by releases of mining-related substances and extensive stream channel and floodplain remediation activities have been conducted in these areas by the BLM. Habitat surveys conducted by R2 Resources predate much of the remediation activities; therefore, the following habitat data and characterization of risk presented for these segments may not accurately reflect current conditions.

The lower half of PineCrkSeg03 lies within the Bunker Hill Superfund site, and has been subject to an ecological risk assessment and remedial actions under the Bunker Hill CERCLA action and Record of Decision.

PineCrkSeg01

Data for bank stability in PineCrkSeg01 are presented in Table 4.1.2.3.6-1. Bank stability scores in this segment are generally high, resulting in a rating of no risk to aquatic receptors. This segment has been subject to extensive remediation activities conducted by the BLM in the riparian zone and floodplain; this has included some bioengineered bank stabilization techniques. Surveys of bank stability preceded implementation of these remediation activities and therefore bank stability is expected to remain high in this segment. It is important to note, however, that the floodplain and riparian areas of this segment lack erodable materials due to the removal of mining-related contaminants. Streambanks in large areas of this segment are composed primarily of large cobbles and boulders, which are immobile except under high flow conditions.

PineCrkSeg02

Data on bank stability in PineCrkSeg02 are shown in Table 4.1.2.3.6-2. RBP and SRI surveys were not conducted in this segment. The BURP score for lower bank stability for this segment is extremely low at 5 percent, corresponding to a high level of risk to aquatic receptors. A level of bank stability this low would indicate extremely degraded ecological conditions in PineCrkSeg02, which has not been indicated in any available references. It is assumed that the BURP survey location is not representative of conditions throughout the segment, and that no characterization of risks to aquatic receptors from bank instability can be made for this segment.

PineCrkSeg03

The riparian zone and floodplain of PineCrkSeg03 have been impacted by mining-related releases of hazardous waste, in addition to road and residential development, and agriculture. The lower half of main stem PineCrkSeg03 lies within the Bunker Hill Superfund site. The upper half of the segment has been subject to remediation actions undertaken by the BLM. Data on bank stability in PineCrkSeg03 are shown in Table 4.1.2.3.6-3. In general, bank stability ratings for this segment are high, corresponding to a rating of no risk to aquatic receptors from bank instability. These ratings are representative of conditions upstream of the urbanized area of lower Pine Creek, which flows through the city of Pinehurst.

4.1.2.3.7 Prichard Creek

Prichard Creek has been subject to mining activities in headwaters and tributary areas. The main stem has been impacted by releases of mining-related hazardous substances and by physical impacts from upstream mining activities, particularly placer mining, which results in large inputs of bedload into the stream channel with destabilizing effects on bank stability.

PrichCrkSeg01

No habitat surveys were conducted by R2 Resources in PrichCrkSeg01 and no other sources of habitat data were identified. Risk to aquatic receptors from bank instability in this segment can not be characterized at this time.

PrichCrkSeg02

No habitat surveys were conducted by R2 Resources in PrichCrkSeg02 and no other sources of habitat data were identified. Risk to aquatic receptors from bank instability in this segment can not be characterized at this time.

PrichCrkSeg03

Habitat surveys were conducted at two locations in PrichCrkSeg03, one location upstream of the town of Murray and one downstream near the confluence with the North Fork Coeur d'Alene River. Average scores for habitat data between these locations and the risk characterization for the segment based on these averages are presented in Table 4.1.2.3.7-1. Bank stability scores for this segment indicate some areas of bank instability, corresponding to a low risk to aquatic receptors.

PrichCrkSeg03 (Eagle Creek)

Eagle Creek is a large tributary to Prichard Creek that is included with main stem Prichard Creek in PrichCrkSeg03. Eagle Creek is examined separately here because habitat conditions in this drainage are considered to be different from conditions in main stem Prichard Creek, and averaging all scores for the segment could lead to a misrepresentation of habitat conditions. BURP habitat surveys were conducted at three locations: East Fork, West Fork, and main stem

Eagle Creek. Average data scores for the Eagle Creek drainage and characterization of risk for aquatic receptors are presented in Table 4.1.2.3.7-2. The average of BURP bank stability scores correspond to a rating of no risk to aquatic receptors; however, the scores are variable among the survey locations in different subdrainages. West Fork Eagle Creek has a BURP lower bank stability score of 100 percent, which corresponds to a rating of no risk. East Fork Eagle Creek has a score of 82.5 percent, which corresponds to a rating of low risk. Main stem Eagle Creek has a score of 77.5 percent, which corresponds to a rating of low risk, near the threshold of a moderate risk rating.

4.1.2.3.8 Beaver Creek—BvrCrkSeg01

The Beaver Creek watershed is tributary to the North Fork Coeur d'Alene River in MidGradSeg03. The entire Beaver Creek watershed lies within BvrCrkSeg01. The headwaters and main stem of the watershed have been subject to mining-related activities and active milling operations continue along main stem Beaver Creek. No habitat surveys were conducted by R2 Resources or the BURP program and no other sources of habitat data for this segment were identified. Risk to aquatic receptors from bank instability in this segment cannot be characterized at this time.

4.1.2.3.9 Middle and Lower South Fork Coeur d'Alene River

Bank stability in the middle and lower portions of South Fork Coeur d'Alene River has been impacted by releases of mining-related hazardous substances, other mining activities, highway construction, urban development, and other anthropogenic activities. In many areas, bank stability is artificially influenced by channelization.

MidGradSeg01

MidGradSeg01 includes the South Fork Coeur d'Alene River from Canyon Creek to Montgomery Creek. The segment includes several tributaries, the largest of which is Placer Creek, which flows into the South Fork Coeur d'Alene River in the town of Wallace immediately downstream of Ninemile Creek. R2 Resources conducted habitat surveys at one location in MidGradSeg01 on the South Fork Coeur d'Alene River. Data for bank stability from that location and the corresponding risk to aquatic receptors are presented in Table 4.1.2.3.9-1. The level of risk associated with bank instability is rated as moderate for MidGradSeg01.

MidGradSeg02

MidGradSeg02 includes the South Fork Coeur d'Alene River from Montgomery Creek downstream to the confluence with the North Fork Coeur d'Alene River. Most of this segment lies within the boundaries of the Bunker Hill Superfund site, and incorporates the towns of Kellogg, Smelterville, and Pinehurst. There are extensive areas of channelization in urban areas of this segment, which has an artificial influence on bank stability. Habitat data were collected at three survey locations near Kellogg, Smelterville, and near Enaville. Bank stability scores and risk characterization for MidGradSeg02 are presented in Table 4.1.2.3.9-2. In spite of bank stabilization functions provided by channelization, habitat data indicate that in several areas streambanks are stable along less than 40 percent of the channel length, corresponding to a high risk to aquatic receptors.

MidGradSeg03

The North Fork Coeur d'Alene River has been less impacted by releases of mining-related hazardous substances than the South Fork Coeur d'Alene River. However, channelization for road construction, agriculture, and residential development, and upstream land uses (including timber harvest) have potentially impacted bank stability.

Habitat surveys were not conducted in MidGradSeg03 in the lower North Fork Coeur d'Alene River and no other sources of bank stability data were available for this analysis. Risk to aquatic receptors from bank instability in this segment cannot be characterized at this time.

4.1.2.3.2 Stream Substrate Composition and Mobility

4.1.2.3.2.1 Risk Characterization CSM Unit 1

Risks to aquatic receptors in CSM Unit 1 from unfavorable substrate composition and mobility characteristics caused by impacts from mining-related hazardous waste are presented below. The risk characterization is organized hierarchically by watershed or drainage, and by CSM segment.

<u>4.1.2.3.2.1.1 Upper South Fork Coeur d'Alene River—UpperSFCDRSeg01</u>

UpperSFCDRSeg01 encompasses the headwaters areas of the South Fork Coeur d'Alene River that have been subject to relatively limited mining-related activity in comparison to the Canyon Creek and Ninemile Creek watersheds. However, mining activity has occurred historically and continues to the present. Mining-related impacts to the riparian zone and floodplain become evident around the Lucky Friday Mine Complex and intensify in the downstream areas of the segment. Historically there have been large inputs of fine- and coarse-grained material to the stream system in the lower reaches of this segment. In addition to mining-related impacts, the South Fork Coeur d'Alene River has been extensively modified for highway construction, secondary roads, and urban development in the central and downstream areas of the segment. All of these factors can have unfavorable impacts on substrate composition and mobility. Typical bottom substrate conditions in the segment are demonstrated in Figures 4.1.2.3-1 to 4.1.2.3-4. Gravel-sized substrate suitable for salmonid spawning is lacking in this stream reach and in much of the segment. In this section of the stream channel, note the lack of large woody debris (LWD), which would typically form stable areas for deposition of suitable spawning substrate.

Data on substrate composition and mobility, interpretation of these data, and the corresponding estimate of risk to aquatic receptors in UpperSFCDRSeg01 are presented in Table 4.1.2.3.2.1.1-1.

Conditions observed in this stream reach indicate that habitat data may not necessarily capture the conditions present. While headwaters reaches show a good diversity of substrate types, channel structure, and LWD influence, conditions appear to degrade progressively downstream of Larson. Observed substrate composition is dominated by large cobble- and boulder-sized substrate with little or no evident gravel-sized substrate present. The channel has a plane bed morphology with predominantly riffle habitat and little LWD retention. The lower reaches of this segment may in fact exhibit high stability, but this is due to degradation of the channel down to armoring cobble- and boulder-sized substrate.

4.1.2.3.2.1.2 Canyon Creek

Substrate composition and mobility in the Canyon Creek watershed vary considerably from the headwaters segments to the mouth of the system at Wallace. The headwaters portions of the watershed are relatively undisturbed, with intact and well-vegetated riparian zones, stable stream banks, and a diverse distribution of substrate types. Canyon Creek has been extensively channelized in the central portion of the watershed to protect roads, residences, and mining-related facilities. In the lower portion of the watershed, there has been extensive modification of the riparian zone and floodplain due to historical mining-related impacts, recovery of mine tailings, and ongoing remediation activities. The lower reaches of the system have been subject to stream restoration activities. Typical substrate conditions in the upper and lower segments of the watershed are shown in Figures 4.1.2.3-5 to 4.1.2.3-12. In general, the stability of bottom substrate in Canyon Creek decreases from upstream to downstream segments. In CCSeg05, there is evidence of mobility in larger cobble- and even boulder-sized substrate (see Figure 4.1.2.3-7).

Data on substrate composition and mobility in the Canyon Creek watershed, interpretation of these data, and the corresponding estimate of risk to aquatic receptors therein are presented below by CSM segment.

CCSeg01
Stream habitat surveys were not conducted in CCSeg01 by R2 Resource Consultants or the BURP program, and no other sources of habitat data have been identified. However, data from CCSeg02 (see following) immediately downstream indicate that substrate composition and mobility conditions are generally good, leading to a conclusion of no risk to aquatic receptors from this measure. Moreover, stream habitat conditions observed in CCSeg01 (Figures 4.1.2.3-5, 4.1.2.3-6) indicate that substrate composition and mobility in this segment are comparable to those observed in CCSeg02 (Figures 4.1.2.3-7, 4.1.2.3-8).

CCSeg02
Data on substrate composition and mobility in CCSeg02, interpretation of these data, and corresponding estimate of risk are presented in Table 4.1.2.3.2.1.2-1. There is a gradient of habitat conditions from the upstream to the downstream end of CCSeg02, with the upstream end demonstrating higher quality habitat (see Figures 4.1.2.3-7, 4.1.2.3-8). Canyon Creek progresses downstream into a zone of increasing channelization and mining-related impacts (see Figure 4.1.2.3-5), reaching its terminus at the opening of an approximately ½-mile-long box culvert under the Hecla mill site at Burke. Conditions at the survey location, however, indicate relatively high habitat quality. As discussed previously, survey locations were selected to be representative of conditions in a given area of a drainage (Reiser 1999). So this location is assumed to be representative of the CSM segment.

Observed conditions in this segment indicate that the low substrate fines scores and higher substrate stability ratings in this segment may in fact reflect the influence of an armored channel that has transported smaller-grained sediments (3 inches or less in diameter) out of the system. The increasing influence of channelization in this segment would support the conclusion that the channel bed is degrading, or has in fact degraded to an armored condition.

Given this conclusion, it is probable that the risks to aquatic receptors from poor substrate composition and mobility conditions are underestimated based on scores available.

CCSeg03

No habitat surveys were conducted in CCSeg03 by R2 Resource Consultants or the BURP program and no other sources of habitat data have been identified for this segment. Floodplain and riparian areas in this segment have been identified by the BLM as impacted by mining-related activities (BLM 1998). However, a risk characterization for aquatic receptors from substrate composition and mobility impacts can not be made at this time.

CCSeg04 and CCSeg05

No habitat surveys were conducted in CCSeg04 by R2 Resource Consultants or the BURP program and no other sources of habitat data were identified in this segment. However, this segment is an area with extensive impacts from mining-related activity and hazardous substances. Conditions in this segment were observed to be similar to those downstream in CCSeg05 (see following), and riparian zone conditions in CCSeg05 have been extrapolated to CCSeg04 in the riparian habitat analysis. Therefore, any level of risk to aquatic receptors from substrate composition and mobility in CCSeg05 is assumed to apply to CCSeg04 as well.

In general, substrate composition and mobility scores for this segment are relatively high (Table 4.1.2.3.2.1.2-2). However, the stream channel in this segment has been degraded by removal of streambank and riparian zone soils, and the stream channel shows evidence of instability. Damage to stream habitat rehabilitation structures visible in Figures 4.1.2.3-11 and 4.1.2.3-12 indicates the potential for mobilization of cobble- to boulder-sized substrate under high flow conditions, indicating that the bottom substrate in this segment is potentially unstable. The relatively high scores for substrate composition and mobility data in this segment conflict with visible evidence of bedload mobility observed in the field.

Characteristic scores for CCSeg05 provide an example of the dependence of habitat data on recent flow history. Habitat surveys were conducted only once in this segment and reflect the stability of the predominant large cobble to boulder substrate present. The evident mobilization of even this large-sized substrate under high flow conditions indicates that the potential for bedload mobility was not captured during the single habitat survey at this location.

Due to the conflict between the level of risk indicated by available habitat data and conditions observed in the field, no risk rating was developed for CCSeg05, or for CCSeg04 by extension. However, conditions observed in the field would tend to indicate that risks to aquatic receptors from this measure are moderate to high.

4.1.2.3.2.1.3 Ninemile Creek

Substrate composition and mobility in the Ninemile Creek watershed vary considerably from the headwaters segments to the mouth of the system at Wallace. The headwaters portions of the watershed are relatively undisturbed, with intact and well-vegetated riparian zones, stable stream banks, and a diverse distribution of substrate types. Mining-related impacts to the stream channel and riparian zone begin at the downstream end of NMSeg01 and continue downstream to the mouth of the system in Wallace. In the lower portion of the watershed, there has been extensive modification of the riparian zone and floodplain due to historical mining-related impacts, recovery of mine tailings, and ongoing remediation activities. The stream system has also been channelized and otherwise modified for road construction, residential development, and other purposes throughout the watershed.

NMSeg01

No habitat surveys were conducted in NMSeg01 by R2 Resources or the BURP program and no other sources of habitat data were identified. NMSeg01 encompasses the headwaters of the Ninemile Creek watershed, which has been subject to historical mining-related activity. Identified areas of mining-related impacts to floodplain and riparian areas begin in the downstream end of this segment. Risks to aquatic receptors from substrate composition and mobility in this segment can not be characterized at this time.

NMSeg02

There is evidence of suboptimal conditions in this segment, resulting in a rating of moderate risk to aquatic receptors for the substrate composition and mobility measure (Table 4.1.2.3.2.1.2-3). Scores for scouring and deposition are variable between RBP and SRI characteristics for this segment. There are two possible explanations for this disparity: the RBP and SRI surveys may have been conducted in different reaches in the approximate area of the identified survey location, or the surveys were performed at different times during the survey period, and the disparity in results reflects the influence of recent flow history on substrate composition and mobility. In either case, the characteristic data indicate variable conditions and the potential for bedload mobility in this segment. These conditions, in conjunction with the high level of substrate fines present indicate degraded substrate composition and mobility in this segment, supporting the moderate risk rating. Given the dependence of these data on recent flow history, the variability in conditions reflected, and the evident potential for bedload mobility, this rating may underestimate risks to aquatic receptors in this segment.

NMSeg03

No habitat surveys were conducted in NMSeg03 by R2 Resources or the BURP program and no other sources of habitat data were identified. NMSeg03 West Fork Ninemile Creek encompasses the headwaters of the Ninemile Creek watershed, which has been subject to historical mining-related activity. There is evidence of deposition of fine-grained sediments in this segment, indicating erosive inputs in upstream areas. The deposition of fine-grained sediments in the lower portion of this segment is encouraged by an impoundment at its downstream end, observed during a field visit in November 1999. However, risks to aquatic receptors from substrate composition and mobility in this segment can not be characterized at this time.

NMSeg04

There is evidence of suboptimal conditions in this segment, resulting in a rating of moderate risk to aquatic receptors for the substrate composition and mobility measure (Table 4.1.2..3.2.1.2-4). As with the lower portion of Canyon Creek watershed, this segment of Ninemile Creek has been subject to extensive historical mining-related impacts. Remedial activities have involved extensive modifications to floodplain and riparian areas in this segment, which, in combination with impacts of mining-related hazardous waste, have adversely affected channel stability.

Substrate composition and mobility characteristic scores in this segment are consistent, corresponding to a moderate risk rating. However, given the potential for an underestimate of risk in NMSeg02 immediately upstream, it is possible that risks in this segment are similarly underestimated.

4.1.2.3.2.1.4 Moon Creek

Moon Creek has been subject to mining-related activities, and riparian areas and floodplains in the watershed have been impacted by releases of mining-related substances. Habitat data for the Moon Creek watershed reflect the impacts of mining-related and other activities on substrate composition and mobility.

MoonCrkSeg01

Habitat quality scores in MoonCrkSeg01 also are generally at the lower end of optimal ranges, resulting in a rating of no risk to aquatic receptors for the substrate composition and mobility measure in this segment (Table 4.1.2.3.2.1.4-1).

MoonCrkSeg02

Habitat quality scores in MoonCrkSeg02 also are generally at the lower end of optimal ranges, resulting in a rating of no risk to aquatic receptors for the substrate composition and mobility measure in this segment (Table 4.1.2.3.2.1.4-2).

4.1.2.3.2.1.5 Big Creek

The Big Creek watershed has had relatively little mining activity in comparison to other watersheds in the South Fork Coeur d'Alene River basin. The upstream segments of the watershed have been the subject of some historical mining exploration, but no extensive mining activities took place in these areas. In addition, road densities in the upstream segments of Big Creek are the lowest of all CSM segments in the basin. The downstream segment of Big Creek has been subject to more extensive mining-related impacts in conjunction with the Sunshine Mine and Mill complex. Releases of mining-related substances have resulted in impacts to floodplain and riparian areas in the lower reaches of Big Creek in BigCrkSeg04.

BigCrkSeg01

There has been little mining-related activity in BigCrkSeg01 and there is little apparent evidence of adverse physical impacts (Table 4.1.2.3.2.1.5-1). Substrate composition and mobility scores for this segment are generally good, although some data category scores are in suboptimal ranges, resulting in a ranking of low risk to aquatic receptors. The brightness score in particular indicates that bed mobility is occurring under low flow conditions, which indicates potential for greater mobility. It is important to note that the survey locations are in the most downstream area of the segment, near forest roads that parallel the stream channel, and they terminate a short distance upstream. The upstream areas of the segment are relatively undisturbed. This suggests that the survey locations are representative of worst-case conditions in the segment. This also suggests that risks to aquatic receptors from substrate composition and mobility are not likely to be due to impacts from mining-related hazardous substances.

BigCrkSeg02

There are no data on bank stability available for BigCrkSeg02, East Fork Big Creek. However, this segment has the lowest road density of any CSM segment in the Coeur d'Alene River basin (1.45 miles/square mile), and little historical mining activity. Based on the conditions present in adjacent segment BigCrkSeg01 and the lack of historical disturbance, best professional judgment was used to assign this segment a rating of no risk to aquatic receptors from substrate composition and mobility due to mining-related hazardous substances.

BigCrkSeg03

As with BigCrkSeg02, no data on bank stability are available for BigCrkSeg03, West Fork Big Creek. Similar to BigCrkSeg02, road densities in this segment are low (1.48 miles/square mile), and there is a lack of large-scale historical or present mining activity, although some evidence of historical activity exists. Therefore, based on best professional judgment, this segment was assigned a rating of no risk to aquatic receptors from substrate composition and mobility due to mining-related hazardous waste.

BigCrkSeg04

Substrate composition and mobility scores for BigCrkSeg04 are generally good, although some data categories scores are in suboptimal ranges, resulting in an estimation of low risk to aquatic receptors (Table 4.1.2.3.2.1.5-2). This segment has been subject to mining-related activities and riparian and floodplain impacts from mining-related hazardous substances associated with the Sunshine Mine and Mill Complex.

4.1.2.3.2.1.6 Pine Creek

The Pine Creek watershed has been subject to extensive mining activity in East Fork Pine Creek (PineCrkSeg01) and along the main stem in the lower reaches of the watershed (PineCrkSeg03). West Fork Pine Creek (PineCrkSeg02) has been subject to little mining-related activity, although other anthropogenic impacts are present. The stream banks and floodplain areas of PineCrkSeg01 and PineCrkSeg03 have been impacted by releases of mining-related substances, and extensive stream channel and floodplain remediation activities have been conducted in these areas by the BLM. Habitat surveys conducted by R2 Resource Consultants predate much of the remediation activity, so habitat data and characterization of risk for these segments may not accurately reflect current conditions.

PineCrkSeg01

Habitat data scores are generally high for PineCrkSeg01 (Table 4.1.2.3.2.1.6-1); however, some characteristics are in suboptimal ranges, including substrate fines and evidence of scouring and deposition along 5 to 10 percent of the survey reach length. While little scouring and deposition is evident in this segment based on characteristic scores, the brightness score indicates that bedload movement is occurring even under the low flow conditions present at the time of the SRI survey. This may indicate a steady state of bedload inputs to and transport through the segment, which would not necessarily result in apparent aggradation or degradation of the channel bed. The suggestion of bedload mobility under low flow conditions results in a finding of moderate risk to aquatic receptors in this segment. If bedload mobility is extensive, this finding may underestimate risks to aquatic receptors in this segment.

This finding is relevant to conditions present in September 1996 when habitat surveys were conducted. Extensive habitat rehabilitation activities have been conducted in PineCrkSeg01 immediately upstream of this segment since that time, and no data are available to evaluate the influence of these activities on substrate composition and mobility.

PineCrkSeg02

Habitat surveys were not conducted in this segment by R2 Resource Consultants or the BURP program and no other sources of data on substrate composition and mobility have been identified. Risks to aquatic receptors from substrate composition and mobility in this segment can not be characterized at this time.

PineCrkSeg03

Habitat data for PineCrkSeg03 generally score in optimal ranges (Table 4.1.2.3.2.1.6-2); however, there is some evidence of active scouring and deposition taking place in some locations. While little scouring and deposition is evident based on characteristic scores, the brightness score indicates that bedload movement is occurring even under the low flow conditions present at the time of the SRI survey. This may indicate a steady state of bedload inputs to and transport through the segment, which would not necessarily result in apparent aggradation or degradation of the channel bed. The suggestion of bedload mobility under low flow conditions results in a finding of low risk to aquatic receptors in this segment. If bedload mobility is extensive, this finding may underestimate risks to aquatic receptors in this segment.

This finding is relevant to conditions present in September 1996 when habitat surveys were conducted. Extensive habitat rehabilitation activities have been conducted in PineCrkSeg01 immediately upstream of this segment since that time, and no data are available to evaluate the influence of these activities on substrate composition and mobility.

4.1.2.3.2.1.7 Prichard Creek

Prichard Creek has been subject to mining activities in headwaters and tributary areas. The main stem has been impacted by releases of mining-related hazardous substances and by physical impacts from upstream mining activities, particularly placer mining, which results in large inputs of bedload into the stream channel with destabilizing effects on stream banks and bottom substrate.

Data on substrate composition and mobility in the Prichard Creek watershed, interpretation of these data, and the corresponding estimate of risk to aquatic receptors therein are presented below by CSM segment.

PrichCrkSeg01 and PrichCrkSeg02
No habitat surveys have been conducted by R2 Resource Consultants or the BURP program in PrichCrkSeg01 or PrichCrkSeg02 and no other sources of habitat data have been identified for these segments. No characterization of risk to aquatic receptors from substrate composition and mobility can be made at this time.

PrichCrkSeg03
Scores for substrate fines in PrichCrkSeg03 are in suboptimal ranges. In addition, the distribution of substrate sizes is normal along 50 to 80 percent of the survey reach length, and scores for substrate mobility indicate evidence of scouring and deposition along less than 5 percent of segment length. The brightness score for this segment indicates mobile substrate over 5 to 35 percent of reach length (Table 4.1.2.3.2.1.7-1). The fact that this is occurring during low flow periods indicates bedload mobility may not have been captured in the scouring and deposition scores. This indicates the potential for greater bedload mobility in the segment under high flow conditions, resulting in a rating of low risk to aquatic receptors despite otherwise favorable data scores.

Eagle Creek is a large tributary stream to lower Prichard Creek, which lies in the northern portion of PrichCrkSeg03. Habitat surveys were conducted by the BURP program in the main stem, East Fork, and West Fork of this drainage, providing data on substrate fines. These data are not included in the evaluation of PrichCreekSeg03 because they are not believed to be representative of conditions in the main stem areas of this segment. Substrate fines percentages for the Eagle Creek drainage are provided in Table F-3.1.1.2.2.2-5 in Appendix F.

4.1.2.3.2.1.8 Beaver Creek - BvrCrkSeg01

No habitat surveys were conducted by R2 Resource Consultants in the Beaver Creek watershed. BURP habitat surveys conducted in the segment found substrate fines percentages at suboptimal levels, as shown in Table 4.1.2.3.2.1.8-1, which indicates that some level of bedload mobility greater than optimal conditions may be occurring in this segment. However, there are insufficient data on substrate composition and mobility in BigCrkSeg01 to draw conclusions about risk to aquatic receptors at this time.

4.1.2.3.2.2 Risk Characterization CSM Unit 2

Risks to aquatic receptors in CSM Unit 2 from unfavorable substrate composition and mobility characteristics caused by impacts from mining-related hazardous waste are presented below. The risk characterization is organized hierarchically by watershed or drainage, and by CSM segment.

4.1.2.3.2.2.1 South Fork Coeur d'Alene River – MidGradSeg01

MidGradSeg01 includes the South Fork Coeur d'Alene River from Canyon Creek to Montgomery Creek. There are extensive areas of channelization in this segment in urban areas, which can influence substrate composition and mobility. The largest of several tributaries to this segment is Placer Creek, which flows into the South Fork Coeur d'Alene River in the town of Wallace, immediately downstream of Ninemile Creek. Data for substrate composition and mobility in MidGradSeg01 are presented in Table 4.1.2.3.2.2.1-1. Habitat data in this segment score in suboptimal to moderate ranges, including deposition of fine-grained sediments in bottom substrate and on river bars and bends, as well as scouring and deposition over 10 to 15 percent of reach length, resulting in filling of pools. These data resulted in a finding of moderate risk to aquatic receptors in this segment.

4.1.2.3.2.2.2 South Fork Coeur d'Alene River – MidGradSeg02

MidGradSeg02 includes the South Fork Coeur d'Alene River from Montgomery Creek downstream to the confluence with the North Fork Coeur d'Alene River. Most of this segment lies within the boundaries of the Bunker Hill Superfund site, and includes the towns of Kellogg, Smelterville, and Pinehurst. There are extensive areas of channelization in urban areas, which can influence substrate composition and mobility. Habitat data for this segment score in optimal to moderate ranges, resulting in a finding of moderate risk to aquatic receptors from substrate composition and mobility (Table 4.1.2.3.2.2.2-1).

4.1.2.3.2.2.3 North Fork Coeur d'Alene River – MidGradSeg03

No habitat surveys have been conducted by R2 Resource Consultants or the BURP program, and no other sources of habitat data have been identified for MidGradSeg03. No characterization of risk to aquatic receptors from substrate composition and mobility can be made at this time.

4.1.2.3.2.2.4 Coeur d'Alene River – MidGradSeg04

No habitat surveys have been conducted by R2 Resource Consultants or the BURP program, and no other sources of habitat data have been identified for MidGradSeg04. No characterization of risk to aquatic receptors from substrate composition and mobility can be made at this time.

4.1.2.3.3 Water Temperature

The instantaneous maximum water temperatures for assessment segments in CSM Units 1 and 2 are shown in Figures 4.1.2.3.3-1 through 4.1.2.3.3-4. Risks to aquatic receptors from high stream temperatures are discussed below. The risk estimation is organized hierarchically by watershed or drainage, and by CSM segment.

Upper South Fork Coeur d'Alene River – UpperSFCDRSeg01

Temperatures were monitored at two locations in UpperSFCDRSeg01 in 1994, 1995, and 1996, using a monitoring station near the headwaters that is representative of habitat conditions in CSM Unit 1 in the absence of extensive mining activity and other large-scale anthropogenic influences on aquatic and riparian habitat (e.g., channelization). Stream temperatures were also monitored at a location near Mullan in 1995 and at a location near the Compressor District in 1996 (Table 4.1.2.3.3-1).

Temperature data taken at the upstream end (headwaters) and in the middle of the segment (Mullan) indicate that there are no risks to aquatic biota from high stream temperatures in these areas of the segment. However, high temperatures in 1994 at Goloconda and July 1996 at the Compressor District (both locations at the downstream end of the segment) exceeded 20°C, corresponding to a moderate risk to aquatic receptors. Mining-related and other anthropogenic impacts to the riparian zone and stream channel of UpperSFCDRSeg01 increase from the middle to lower end of the segment, with corresponding impacts on stream temperatures.

Canyon Creek – CCSeg05

Temperatures were monitored at locations in CCSeg05 in 1994, 1995, and 1996. These locations are below an extensive area of mining-related impacts on riparian zone vegetation and stream channel morphology.

Temperature conditions in CCSeg05 in 1995, a moderate temperature year for the Coeur d'Alene River basin, indicate a low risk to aquatic receptors (Table 4.1.2.3.3-2). However, the high temperatures in CCSeg05 in 1994 and again in 1996, both warm weather years, exceeded 22°C. The high temperature of 24.1°C in 1994 in particular indicates that a high risk to aquatic receptors exists in CCSeg05 from high stream temperatures.

As CCSeg05 lies on the downstream end of an increasing gradient of mining-related and other anthropogenic impacts to Canyon Creek, it is assumed that there is an increasing gradient of temperature from upstream to downstream segments. As shown in Figure 4.1.2.3-5, habitat conditions in CCSeg01, the headwaters area of Canyon Creek, are relatively intact. It is assumed that temperatures in this segment will be comparable to reference conditions in Placer Creek (maximum temperatures of 13.4 and 14.9°C in 1995 and 1996, respectively). As the level of anthropogenic disturbance increases moving downstream through CCSeg02, CCSeg04, and CCSeg05, temperatures are expected to increase. No conclusions are made regarding water temperature in CCSeg03 because of a lack of available data.

Ninemile Creek – NMSeg04

Temperatures were monitored at locations in NMSeg04 in 1994, 1995, and 1996. These locations are below an extensive area of mining-related impacts on riparian zone vegetation and stream channel morphology.

Temperature conditions in NMSeg04 in 1995, a moderate temperature year for the Coeur d'Alene River basin, indicate a low risk to aquatic receptors (Table 4.1.2.3.3-3). However, the high temperature in 1994 reached 26.1 °C, well above the threshold for high risk to aquatic receptors. In 1996 temperatures again exceeded the high risk threshold, reaching a maximum of 22.7 °C. As with Canyon Creek, the headwaters area of Ninemile Creek has received a relatively low degree of mining-related impacts, with the gradient of mining-related and other anthropogenic disturbances increasing downstream. Therefore, as the level of anthropogenic disturbance increases moving downstream through NMSeg01, NMSeg02, and NMSeg04, temperatures are expected to increase. Ninemile Creek differs from Canyon Creek in that extensive timber harvest activities have been conducted recently in the headwaters area of this watershed. Detrimental impacts from increased sedimentation have the potential to affect stream temperatures throughout the main stem areas of the watershed. No conclusions are made regarding water temperature in NMSeg03 due to lack of data.

Moon Creek – MoonCrkSeg02

Stream temperatures were monitored only in MoonCrkSeg02 during 1996, which can be considered the warmer year of the 1995 and 1996 monitoring periods. An instantaneous maximum temperature of 18.1 °C was recorded on Moon Creek in July 1996 (Table 4.1.2.3.3-4). The temperature conditions indicated by available data correspond to a low risk to aquatic receptors using established criteria. No temperature data were available for the 1994 warm weather year.

Big Creek – BigCrkSeg04

Stream temperatures were monitored at locations in BigCrkSeg04 in 1994, 1995, and 1996, at the downstream end of a zone of mining-impacted riparian and stream habitat. Big Creek has a relatively large drainage area for South Fork Coeur d'Alene River tributaries; the majority of it lies above areas with extensive anthropogenic impacts.

The instantaneous maximum temperatures of 20.4 and 20.6 °C recorded in 1994 and 1996, respectively, indicate that a moderate risk to aquatic receptors from high temperatures exists in this segment (Table 4.1.2.3.3-5). Based on the low degree of anthropogenic impacts in the remainder of the watershed, it is assumed that water temperatures in the remaining segments will be no higher and probably lower than those found in BigCrkSeg04.

Pine Creek – PineCrkSeg03

Stream temperatures were monitored at locations in PineCrkSeg03 in 1994, 1995, and 1996. The Pine Creek drainage has extensive areas of riparian and floodplain habitat that have been impacted by mining-related and other anthropogenic influences, particularly in PineCrkSeg03 and PineCrkSeg01, East Fork Pine Creek. PineCrkSeg02, West Fork Pine Creek, constitutes a large portion of the Pine Creek watershed and has been subject to relatively few mining-related impacts.

Instantaneous maximum temperatures measured in PineCrkSeg03 were below 18°C in both 1995 and 1996. Temperatures in the warm weather year of 1994 reached 18.1°C, qualifying as a low risk to aquatic receptors in this segment (Table 4.1.2.3.3-6). Based on these data, it is inferred that instantaneous maximum temperatures in PineCrkSeg02 are also below 18°C, as there have been fewer anthropogenic impacts in this segment than other areas in the Pine Creek watershed. PineCrkSeg01 has been subject to extensive mining-related impacts in the riparian zone, and extensive riparian habitat rehabilitation efforts have been implemented recently. However, there are no temperature data for this segment.

Prichard Creek – PrichCrkSeg03

Stream temperatures were monitored in lower Prichard Creek (PrchCrkSeg03) in 1994 and 1995. High temperatures in July and August of 1995 reached only 15.1°C, well below the defined risk criteria (Table 4.1.2.3.3-7). Temperatures in the warm weather year of 1994 reached 17.3°C, also below risk criteria. Temperature surveys were not conducted in the remaining upstream segments of Prichard Creek. However, low stream temperatures in the downstream reaches of the watershed suggest that temperature conditions in headwaters areas are below risk thresholds. This suggestion is not conclusive, however, as high stream temperatures in upstream areas of Prichard Creek could be moderated in downstream areas below confluences with cooler water tributaries.

Middle South Fork Coeur d'Alene River – MidGradSeg01

Stream temperatures were monitored at two locations in MidGradSeg01 in 1995 and at one location in 1994 and 1996. Stream temperatures upstream of Big Creek, at the downstream end of MidGradSeg01, reached 18.5°C in 1995. This corresponds to a low risk to aquatic receptors. Stream temperatures in 1994 near Big Creek reached 22.5°C, which constitutes a high risk to aquatic receptors in this portion of the segment (Table 4.1.2.3.3-8). In 1996 stream temperatures at Lake Gulch, the upstream end of the segment, reached 20.4°C, corresponding to a moderate risk to aquatic receptors. The level of risk achieved during 1996 at a survey location farther upstream suggests that stream temperatures in the downstream area of MidGradSeg01 were even higher. This conclusion is supported by the fact that temperatures in Big Creek, a significant tributary to the segment, reached 20.6°C in July of 1996, meaning that there was a significant influx of warm water to the system. In addition, stream temperatures measured in the upstream end of MidGradSeg02 at Kellogg in July 1996 exceeded 22°C (see following section), suggesting that water leaving MidGradSeg01 was at temperatures approaching or exceeding the high risk threshold during 1996. The temperature profile suggested for 1996, and the high temperatures achieved in 1994, indicate that there is a high level of risk to aquatic receptors from high stream temperatures in the downstream area of this segment.

Lower South Fork Coeur d'Alene River – MidGradSeg02

Stream temperatures were monitored at two locations in MidGradSeg02 in 1995, and at one location in 1994 and 1996. Stream temperatures in July 1995 reached a high of 18.6°C, corresponding to a low level of risk to aquatic receptors (Table 4.1.2.3.3-9). Temperatures in July 1996 reached a high of 22.1°C at Kellogg, and 21.2°C at Enaville, corresponding to high and moderate levels of risk to aquatic receptors, respectively. The decrease in stream temperatures between Kellogg and Enaville may reflect the input of cooler waters from Pine Creek (see Table 4.1.2.3.3-6). However, stream temperatures below Pine Creek in 1994 reached a high of 23.1°C, corresponding to a high level of risk to aquatic receptors. Overall, the conclusion for MidGradSeg02 is that stream temperatures can pose a high level of risk to aquatic receptors in given areas under warm weather conditions.

Lower North Fork Coeur d'Alene River – MidGradSeg03

Stream temperatures were monitored in MidGradSeg03 in 1994 and 1995 at one location. Stream temperatures reached a maximum of 18.7°C in July 1995, which corresponds to a low level of risk to aquatic receptors (Table 4.1.2.3.3-10). The North Fork Coeur d'Alene River has had few mining-related impacts to its floodplain and riparian zones, suggesting that relatively high temperatures may be either a natural condition in this system, or due to the influences of non-mining-related activities in the main stem and tributary areas of this system. This conclusion is supported by the temperature profile of the middle reaches of the St. Joe River in 1995 (Figure 3.2.2.3-1), which also exceed risk criteria. The maximum temperature in 1994 reached 21.1°C, corresponding to a moderate risk to aquatic receptors. The 1994 data are viewed cautiously however, as there are no data for comparison in reference streams from that year. The overall conclusion for this segment is that there is a low risk to aquatic receptors from high stream temperatures, which may be more heavily influenced by non-mining-related impacts to habitat quality.

Upper Main Stem Coeur d'Alene River – MidGradSeg04

Stream temperatures were monitored in MidGradSeg04 in 1995. A maximum temperature of 18.8°C was recorded in July of that year, which corresponds to a low level of risk to aquatic receptors (Table 4.1.2.3.3-11). This segment of the Coeur d'Alene River lies below the confluence of the South Fork Coeur d'Alene River (which has demonstrated stream temperatures constituting a moderate risk to aquatic receptors) and the slightly cooler MidGradSeg03 of the North Fork Coeur d'Alene River. (As discussed above, stream temperatures in MidGradSeg03 corresponded to a low level of risk in 1995.) Stream temperatures in this segment reflect mixing of the relatively warm waters of the South Fork Coeur d'Alene River and the larger volume of cooler water from the North Fork Coeur d'Alene River. Temperature data were not collected in MidGradSeg04 in the warmer weather years of 1994 and 1996.

4.1.2.3.4 Habitat Suitability Index Model for the Riparian Habitat

Boxplots for each of the assessment segment and the reference area are shown in Figure 4.1.2.3.4-1. Again, the composite reference area comparison is valid only for segments in CSM

Units 1 and 2. The interquartile ranges for segments CCSeg05, NMSeg02, MidGradSeg01, and MidGradSeg02 are lower than the interquartile range for the reference area, suggesting that there are large differences between these assessment segments and the reference area. On the other hand, the interquartile ranges for segments MidGradSeg03 and MidGradSeg04 fall within the interquartile range for the reference area, suggesting that these populations are similar.

Results of the Mann-Whitney test are shown in Table 4.1.2.3.4-1. Segments CCSeg05, NMSeg02, MidGradSeg01and MidGradSeg02 have significantly lower HSI scores than the reference area. HSI scores for MidGradSeg03 and MidgradSeg04 were not significantly different from the reference area.

4.1.2.3.4.1 CSM Unit 1 - Canyon Creek and Ninemile Creek

Canyon Creek

Riparian vegetation quality and the associated HSI decreases along Canyon Creek from the headwaters to the confluence with the South Fork Coeur d'Alene River at Wallace. The upper segments of Canyon Creek (CCSeg01 and CCSeg02, a riparian vegetation reference area) have relatively intact riparian vegetation with high habitat complexity. The lower portion of Canyon Creek (CCSeg04 and CCSeg05) has been heavily impacted by mining and urban development.

Habitat restoration work was conducted by the Silver Valley Trustees in the 1990s along most of the lower portion of Canyon Creek (CCSeg05). The restoration work included attempts to reestablish native vegetation in the riparian zone. Field observation following restoration showed that high flows have impacted many of the constructed habitat features and plant survival is low (Heinle 1999). Wesche (1999) confirmed these observations by concluding that stream bank vegetation quality was rated as poor to marginal during a 1999 habitat survey.

HSI data from the riparian resources injury assessment (Hagler Bailly 1995) were available for Canyon Creek segments CCSeg02 (reference area), CCSeg04, and CCSeg05.

Six riparian sample sites were located in CCSeg05 just south of the boundary with CCSeg04 (Figure 3.1.1.2.2.10-1). These six sample sites were used to represent the HSI for CCSeg05 and they were also used to represent the HSI for CCSeg04. This extrapolation is justified because:

- CCSeg04 and CCSeg05 are downgradient from Burke and have received similar levels of mining- and nonmining-related impacts. Since the six sample sites occur near the boundary between CCSeg04 and CCSeg05, the average HSI for the sites is expected to be representative of both segments.

- The percent bare ground estimated from the modified BLM vegetative cover map for the two segments is similar (93 percent bare ground for CCSeg04 and 95 percent bare ground for CCSeg05) suggesting a similar riparian vegetation status.

- Experts familiar with the ecology of Canyon Creek believe that CCSeg04 and CCSeg05 are comprised of riparian vegetation of similar diversity and abundance (LeJeune 2000; Eno 2000).

Therefore, results of the HSI analysis for CCSeg05 were used to represent the HSI for CCSeg04. It is concluded that the HSI for segment CCSeg04 is degraded.

The boxplot for CCSeg05 shows that the interquartile range for the HSI falls below the interquartile range for the reference area and that the median values are distinct, suggesting these sample populations are quite different. The difference in median values is confirmed by the Mann-Whitney test, which showed that CCSeg05 was significantly different from the reference area. It is concluded that the HSI for segment CCSeg05 is degraded.

Ninemile Creek

Riparian vegetation quality and the associated HSI decreases along Ninemile Creek from the headwaters to the confluence with the South Fork Coeur d'Alene River at Wallace. The upper segments of Ninemile Creek (NMSeg03, a riparian vegetation reference area, and presumably NMSeg01) have relatively intact riparian vegetation with high habitat complexity. The lower portion of Ninemile Creek (NMSeg02 and NMSeg04) has been heavily impacted by mining and urban development.

Habitat restoration work was conducted by the Silver Valley Trustees in the 1990s along most of NMSeg02 and NMSeg04. The restoration work included attempts to reestablish native vegetation in the riparian zone. Field observation following restoration showed that high flows have impacted many of the constructed habitat features and plant survival is low (Heinle 1999). Wesche (1999) confirmed these observations by concluding that stream bank vegetation quality was rated as poor to marginal during a 1999 habitat survey.

HSI data from the riparian resources injury assessment (Hagler Bailly 1995) were available for Ninemile Creek segments NMSeg02, NMSeg03 (reference area), and NMSeg04.

The boxplot for NMSeg02 shows that the interquartile range for the HSI falls below the interquartile range for the reference area and that the median values are distinct, suggesting these sample populations are quite different. The difference in median values is confirmed by the Mann-Whitney test, which showed that NMSeg02 was significantly different from the reference area. It is concluded that the HSI for segment NMSeg02 is degraded.

Five riparian sample sites were located in NMSeg02 just north of the boundary with NMSeg04 (Figure 3.1.1.2.2.10-1). These five sample sites were used to represent the HSI for NMSeg02 and they will also be used to represent the HSI for NMSeg04. This extrapolation is justified because:

- The sample sites occur near the border between NMSeg02 and NMSeg04 and Wesche (1999) found the stream bank vegetation condition for the portion of Ninemile Creek from the Interstate Mine to Wallace, which includes NMSeg02 and NMSeg04, was ranked as marginal throughout.

- The percent bare ground estimated from the modified BLM vegetative cover map for the two segments is similar (72 percent bare ground for NMSeg02 and 74 percent bare ground for NMSeg04), suggesting a similar riparian vegetation status.

- Experts familiar with the ecology of Ninemile Creek believe that NMSeg02 and NMSeg04 are comprised of riparian vegetation of similar diversity and abundance (LeJeune 2000; Eno 2000).

Therefore, results of the HSI analysis for NMSeg02 will be used to represent the HSI for NMseg04. It is concluded that the HSI for NMSeg04 is degraded.

4.1.2.3.4.2 CSM Unit 2 – South Fork Coeur d'Alene River, Lower North Fork Coeur d'Alene River, and Upper Coeur d'Alene River

Riparian vegetation quality and the associated HSI were highly variable within CSM Unit 2. The midgradient segments of the South Fork Coeur d'Alene River (MidGradSeg01 and MidGradSeg02) have been heavily impacted by mining and urban development. The lower portion of the North Fork Coeur d'Alene River has had much less impact from mining and urban development than the midgradient segments of the South Fork. The upper portion of the Coeur d'Alene River has been impacted by mining-related hazardous substances that have migrated down from the South Fork Coeur d'Alene River, but riparian vegetation quality and HSI have not been overtly impacted.

HSI data from the riparian resources injury assessment (Hagler Bailly 1995) were available for all segments within CSM Unit 2.

The boxplot for MidGradSeg01 shows that the interquartile range for the HSI falls below the interquartile range for the reference area and that the median values are distinct, suggesting these sample populations are quite different. The difference in median values is confirmed by the Mann-Whitney test, which showed that MidGradSeg01 was significantly different from the reference area. It is concluded that the HSI for segment MidGradSeg01 is degraded.

The boxplot for MidGradSeg02 shows that the interquartile range for the HSI falls below the interquartile range for the reference area and that the median values are distinct, suggesting these sample populations are quite different. The difference in median values is confirmed by the Mann-Whitney test, which showed that MidGradSeg02was statistically significantly different from the reference area. It is concluded that the HSI for segment MidGradSeg02is degraded.

The boxplot for MidGradSeg03 shows that the interquartile range for the HSI falls within the interquartile range for the reference area and that the medians are similar, suggesting these sample populations are not different. The similarity in median values was confirmed by the Mann-Whitney test, which showed that MidGradSeg03 was not statistically different from the reference area. It is concluded that the HSI for segment MidGradSeg03 is not degraded.

The boxplot for MidGradSeg04 shows that the interquartile range for the HSI falls within the interquartile range for the reference area and that the medians are similar, suggesting these sample populations are not different. The similarity in median values was confirmed by the Mann-Whitney test, which showed that MidGradSeg04 was not statistically different from the reference area. It is concluded that the HSI for segment MidGradSeg04 is not degraded.

4.1.2.3.4.3 CSM Unit 3 – Mid and Lower Coeur d'Alene River

Riparian vegetation quality and the associated HSI were relatively high within CSM Unit 3. There is considerably less urban development in CSM Unit 3 compared to CSM Units 1 and 2. Agriculture is practiced on roughly 10,000 acres within the floodplain. In addition, the hydrology of the lower Coeur d'Alene River and its floodplain has been highly modified through the creation of Post Falls dam and diking, channelization, and shoreline development. These alterations have disrupted the natural meander patterns of the river and fragmented the hydraulic connectivity between the river and lateral lakes and wetlands.

HSI data from the riparian resources injury assessment (Hagler Bailly 1995) were available for LCDRSeg01, LCDRSeg02, LCDRSeg03, LCDRSeg04, and LCDRSeg05.

Figure 4.1.2.4.5-1 shows the HSIs for sampling sites in CSM Unit 3. Segments LCDRSeg01, LCDRSeg02, LCDRSeg03, LCDRSeg04, and LCDRSeg05 have median values ranging from approximately 0.3 to 0.5. Although no definitive conclusions can be drawn from this information, overt signs of degradation in HSI are not readily apparent. This conclusion is substantiated by the lack of degradation in vegetative community characteristics for these same segments (see Section 4.1.2.1).

4.1.2.3.5 Suspended Solids

The severity of effect scores for suspended solids and risks for each individual segment for which data exist are summarized by segment in Table 4.1.2.3.5-1, which presents severity of effect and risk estimates for a 24-hour exposure duration, and Table 4.1.2.3.5-2, which presents severity of effect and risk estimates for a 2-hour exposure duration. (Measured suspended solids concentrations and the estimated severity of effect for each measured suspended solids data point are presented in Appendix F Tables F-3.1.1.2.2.6-1 and F-3.1.1.2.2.6-2, respectively.) Risks are described individually for each segment. In general, estimated risks were greatest for fish eggs and larvae and smallest for juvenile and adult salmonids.

4.1.2.3.5.1 LCDRSeg01

Measured suspended solids concentrations for LCDRSeg01 ranged between 1.9 and 890 mg/L, with a median of 66 mg/L. The severity of effects scores for the 24-hour duration were short-term minor to major sublethal for juvenile/adult salmonids, and major sublethal for fish eggs/larvae and adult nonsalmonid fish. Results of the 24-hour effects comparisons suggest a low to moderate potential for ecological risk. The 2-hour duration severity of effects scores for all receptors ranged from short-term minor to major sublethal, suggesting a low to moderate potential for ecological risk.

Risks at LCDRSeg01 appear slightly elevated (maximum 24-hour severity of effect score of 9, based on Newcombe and Jensen [1996] regressions) compared to the St. Joe River reference site (maximum 24-hour severity of effect score of 8) for juvenile and adult salmonids at the 24-hour exposure duration and all receptors at the 2-hour exposure duration.

4.1.2.3.5.1 LCDRSeg02

Measured suspended solids concentrations for LCDRSeg02 ranged between 1 and 980 mg/L, with a median of 6 mg/L. The severity of effects scores for the 24-hour duration were short-term minor to major sublethal for juvenile/adult salmonids, and major sublethal for fish eggs/larvae and adult nonsalmonid fish. Results of the 24-hour effects comparisons suggest a low to moderate potential for ecological risk. The 2-hour duration severity of effects scores for all receptors ranged from short-term minor to major sublethal, suggesting a low to moderate potential for ecological risk.

Risks at LCDRSeg02 appear slightly elevated (maximum severity of effect score of 9) compared to the St. Joe River reference site for juvenile and adult salmonids at the 24-hour exposure duration and all receptors at the 2-hour exposure duration.

4.1.2.3.5.3 LCDRSeg03

Measured suspended solids concentrations for LCDRSeg03 ranged between 1 and 51 mg/L, with a median of 26 mg/L. The severity of effects scores for the 24-hour duration were short-term minor to major sublethal for juvenile/adult salmonids, and major sublethal for fish eggs/larvae and adult nonsalmonid fish. Results of the 24-hour effects comparisons suggest a low to moderate potential for ecological risk. The 2-hour duration severity of effects scores for juvenile/adult salmonids was short-term minor, and for fish eggs/larvae and adult nonsalmonids the severity of effects scores ranged from short-term minor to major sublethal. Results of the 2-hour duration evaluation suggest a low to moderate potential for ecological risk.

Risks at LCDRSeg03 appear comparable to those at the St. Joe River reference site for juvenile/adult salmonids at the 24-hour exposure duration, and for the fish eggs/larve and adult nonsalmonids at the 2-hour exposure duration. This conclusion, however, is based on only two suspended solids measurements.

4.1.2.3.5.4 LCDRSeg04

Measured suspended solids concentrations for LCDRSeg04 ranged between 1.9 and 43.5 mg/L, with a median of 23 mg/L. The severity of effects scores for the 24-hour duration were short-term minor to major sublethal for juvenile/adult salmonids, and major sublethal for fish eggs/larvae and adult nonsalmonid fish. Results of the 24-hour effects comparisons suggest a low to moderate potential for ecological risk. The 2-hour duration severity of effects scores for juvenile/adult salmonids was short-term minor, and for fish eggs/larvae and adult nonsalmonids the severity of effects scores ranged from short-term minor to major sublethal. Results of the 2-hour duration evaluation suggest a low to moderate potential for ecological risk.

Risks at LDCRSeg04 appear comparable to those at the St. Joe River reference site for juvenile/adult salmonids at the 24-hour exposure duration, and for the fish eggs/larve and adult nonsalmonids at the 2-hour exposure duration. This conclusion, however, is based on only two suspended solids measurements.

4.1.2.3.5.5 LCDRSeg05

Measured suspended solids concentrations for LCDRSeg05 ranged between 3 and 620 mg/L, with a median of 29 mg/L. The severity of effects scores for the 24-hour duration were short-term minor to major sublethal for juvenile/adult salmonids, and major sublethal for fish eggs/larvae and adult nonsalmonid fish. Results of the 24-hour effects comparisons suggest a low to moderate potential for ecological risk. The 2-hour duration severity of effects scores for all receptors ranged from short-term minor to major sublethal, suggesting a low to moderate potential for ecological risk.

Risks at LCDRSeg05 appear slightly elevated (maximum 24-hour severity of effect score of 9) compared to the St. Joe River reference site for juvenile/adult salmonids at the 24-hour exposure duration, and for all receptors at the 2-hour exposure duration.

4.1.2.3.5.6 LCDRSeg06

Measured suspended solids concentrations for LCDRSeg06 ranged between 6 and 52 mg/L, with a median of 26 mg/L. The severity of effects scores for the 24-hour duration were short-term minor to major sublethal for juvenile/adult salmonids, and major sublethal for fish eggs/larvae and adult nonsalmonid fish. Results of the 24-hour effects comparisons suggest a low to moderate potential for ecological risk. The 2-hour duration severity of effects scores for juvenile/adult salmonids was short-term minor, and for fish eggs/larvae and adult nonsalmonids the severity of effects scores ranged from short-term minor to major sublethal. Results of the 2-hour duration evaluation suggest a low to moderate potential for ecological risk.

Risks at LCDRSeg06 appear similar to those at the St. Joe River reference site for juvenile/adult salmonids at the 24-hour exposure duration and for the fish eggs/larve and adult nonsalmonids at the 2-hour exposure duration.

4.1.2.3.5.7 SpokaneRSeg01

Measured suspended solids concentrations for SpokaneRSeg01 ranged between less than 1 and 8 mg/L, with a median of 2 mg/L. The severity of effects scores for the 24-hour duration were short-term minor for juvenile/adult salmonids, and major sublethal for fish eggs/larvae and adult nonsalmonid fish. Results of the 24-hour effects comparisons suggest a low to moderate potential for ecological risk. The 2-hour duration severity of effects scores for all receptors was short-term, suggesting a low potential for ecological risk.

Potential risks from suspended solids at SpokaneRSeg01 appear similar to those at the St. Joe River reference site.

4.1.2.3.6 Sediment Deposition Rate

Risk estimates for measured sedimentation rates are presented in Table 4.1.2.3.6-1. Risk estimates for individual segments within CSM Units 3 and 4 are discussed below. The water level of all 12 lateral lakes is controlled by Post Falls dam on the Spokane River, making the lakes' water levels identical to Coeur d'Alene Lake. Hydrological controls on sediment deposition rates should therefore be similar throughout the lateral lakes, main stem Coeur d'Alene River, and Coeur d'Alene Lake. Water movement, such as wave action and currents, sorts particulate matter according to size and density. The result—at least in the deeper portions of the lateral lakes, main stem Coeur d'Alene River, and Coeur d'Alene Lake—is that little energy is available to maintain particulate matter in suspension. Most aquatic portions of CSM Units 3 and 4 are sediment deposition areas. Exceptions are those portions of the main stem Coeur d'Alene River with more lotic characteristics, the shallower littoral portions of the basin most affected by water level fluctuations at Post Falls dam, and the more unstable portions of the Coeur d'Alene River delta.

4.1.2.3.6.1 LCDRSeg02

A measured sediment deposition rate is available from Bull Run Lake (Rabbi 1994). Since the installation of sedimentation ponds throughout the Coeur d'Alene River basin in 1968 and 1969, the annual deposition rate in Bull Run Lake has averaged 0.35 cm/yr for the period between 1968 and 1991. This average deposition rate is typical of that throughout the lower Coeur d'Alene River basin prior to mining, and is interpreted as posing little or no ecological risk to benthic species.

4.1.2.3.6.2 LCDRSeg04

Sediment deposition rates are available for three lateral lakes within this segment: Killarney, Medicine and Swan Lakes. Bender (1991) measured a sedimentation rate of 0.87 cm/yr for Killarney Lake between the installation of sedimentation ponds in the Coeur d'Alene River basin in 1968 and collection of the core in 1988. The same core also had a measured deposition rate of 0.09 cm/yr from 6700 B.P. to the onset of substantial mining activities in the basin around 1880. The historical deposition rate of 0.09 cm/yr was uncorrected for compaction of the core, and may be an underestimate of the true average pre-mining deposition rate. The 1968 to 1988 deposition rate appears to be somewhat elevated compared to historical norms in the basin, and is rated as having a moderate potential to pose ecological risks to resident benthic species.

Rember et al. (1993) and Hoffman (1995) both report sedimentation rate estimates for cores from Medicine Lake. Their 1968 to 1991 sedimentation rate estimates are nearly identical at 0.42 and 0.40 cm/yr, respectively. Both of these sedimentation rates are within the range of pre-mining or mining-unimpacted sedimentation rates within the basin, and are believed to pose little or no ecological risk to resident benthic biota.

Rabbi (1994) provides a sediment deposition rate estimate of 0.26 cm/yr for Swan Lake between 1968 and 1991. This sedimentation rate is within the range of historical pre-mining or mining-unimpacted rates within the basis. As such, it is believed to pose little or no ecological risk to resident benthic biota.

4.1.2.3.6.3 LCDRSeg06

A core sample (core 123) was collected by Hoffman (1995) at the mouth of the Coeur d'Alene River exactly on the dividing line between LCDRSeg06 (the segment of the main stem Coeur d'Alene River farthest downstream) and CDALakeSeg02, one of three segments within Coeur d'Alene Lake. Core 123 of Hoffman et al. (1995) is used to estimate sediment deposition in the delta of the Coeur d'Alene River. The sediment deposition rate between 1980 and 1990 averaged 2.1 cm/yr. This rate of sedimentation is substantially higher than that observed prior to 1880 or in mining-unimpacted regions of the basin. The elevated sedimentation rate is believed to have a high potential to pose adverse ecological risks to benthic biota.

4.1.2.3.6.4 CDALakeSeg01

Horowitz et al. (1993) found sedimentation rates of 0.3 - 0.5 cm/yr in the portion of Coeur d'Alene Lake south of the mouth of the Coeur d'Alene River. As this area is not believed to receive significant inputs of sediment from the Coeur d'Alene River (Horowitz et al. 1993), it was chosen to represent what present day conditions would be like in the basin in the absence of mining impacts. CDALakeSeg01 is south of the mouth of the Coeur d'Alene River, whereas the Spokane River, the only outlet of Coeur d'Alene Lake, is at the northern end of the lake. The net flow of water in the lake is from south to north, which is the basis for the belief that CDALakeSeg01 receives little or no input of mining-associated material from the Coeur d'Alene River. The sedimentation rate of 0.3 to 0.5 cm/yr is rated as having little or no potential to pose adverse ecological risks. One sample (core 8) collected by Horowitz et al. (1995) from CDALakeSeg01 was found to have a sediment deposition rate of 0.96 cm/yr. While core 8 of Horowitz et al. (1995) has a deposition rate that is somewhat higher than other portions of Coeur d'Alene Lake, which do not receive significant mining-associated sediment inputs, it is located in a portion of the lake that does not receive mining waste inputs. The somewhat elevated deposition rate of core 8 therefore does not reflect mining-related risks.

4.1.2.3.6.5 CDALakeSeg02

This segment of Coeur d'Alene Lake, which consists of the entire lake basin north of the mouth of the Coeur d'Alene River with the exception of Wolf Lodge Bay, has five dated sediment cores available (Horowitz et al. 1995) from which sedimentation rates can be determined (six, if core 123 is located in CDALakeSeg02 instead of Coeur d'Alene segment LCDRSeg06). The average sedimentation rates from 1980 to 1990 range between 0.03 and 2.15 cm/yr for this segment (Table 3.1.1.2.2.8-1). Core 6 is located approximately 2 miles northwest of the mouth of the Coeur d'Alene River. Based on the available data, it appears that sedimentation rates in the vicinity of the mouth of the Coeur d'Alene River, both within the river itself and Coeur d'Alene Lake, are somewhat elevated compared to both historical norms and the rest of the basin. Core 6 has an average sedimentation rate of 0.58 cm/yr, slightly above the sedimentation rates observed in pre-mining core data or in mining-unimpacted portions of the basin. Core 6 is rated as having a moderate potential to pose adverse ecological risks to benthic biota.

With the exception of core 6 and core 123 (discussed under LCDRSeg06), all other cores from CDALakeSeg02 have average sediment deposition rates of 0.36 cm/yr or lower. These cores

(cores 47, 71, 93, 9) all are indicative of sedimentation rates that have little or no potential to pose adverse ecological risks to benthic biota (Table 4.1.2.3.6-1).

4.1.2.3.6.6 CDALakeSeg03

This segment consists of Wolf Lodge Bay at the northeastern extremity of Coeur d'Alene Lake. Sediments within portions of Wolf Lodge Bay do not have the elevated trace metal concentrations found throughout most of Coeur d'Alene Lake, indicating that the bay may not receive a substantial quantity of sediment from the Coeur d'Alene River. The deposition rate in the bay averaged 0.23 cm/yr between 1980 and 1990, within the range of deposition rates found pre-mining and within mining-unimpacted portions of the basin. Horowitz et al. (1993) believe that the trace metal concentrations in recently deposited Wolf Lodge Bay sediments indicate that sediments from the Coeur d'Alene River are not deposited in Wolf Lodge Bay in appreciable quantities. This being the case, deposition rate data from Wolf Lodge Bay (CDALakeSeg03), along with deposition rate data from the St. Joe arm of Coeur d'Alene Lake (CDALakeSeg01), are considered representative of deposition rates in the absence of mining-related impacts on sediment deposition rates. As deposition rate data from Wolf Lodge Bay were used in Section 3.2.2.3.8 to derive the ecological effect measure for sediment deposition rates, no risk estimates from sediment deposition rates are calculated for CDALakeSeg03.

4.1.2.3.7 Spatial Distribution and Connectivity

Risk ratings for the spatial distribution and connectivity measure for riverine habitats in CSM Units 1, 2, and 3 are presented in Table 4.1.2.3.7-1. The table includes a two-category summary of risk ratings for the riverine habitat measures of ecosystem and receptor characteristics for these segments: no-to-low risk and moderate-to-high risk. An interpretive explanation accompanies the rating for each segment or watershed as appropriate. Summary risk ratings for riverine habitat measures are presented graphically in Figure 4.1.2.3.7-1. The spatial isolation of habitats with no-to-low risk rating by extensive areas of degraded habitat is demonstrated in this figure. Risk ratings for the spatial distribution and connectivity measure are shown in Figure 4.1.2.3.7-2.

Risk ratings for the spatial distribution and connectivity measure in riparian habitats in CSM Units 1, 2, and 3 are presented in Table 4.1.2.3.7-2, with a similar format to the risk rating table for riverine habitats. Summary risk ratings for riparian habitat measures of ecosystem and receptor characteristics (excluding the spatial distribution and connectivity measure) are presented graphically in Figure 4.1.2.3.7-3. The spatial isolation of habitats with no-to-low risk ratings by extensive areas of degraded habitat is demonstrated in this figure. Risk ratings for the spatial distribution and connectivity measure for riparian habitats are presented graphically in Figure 4.1.2.3.7-4.

4.2 RISK DESCRIPTION

4.2.1 Aquatic Organisms

Concentrations of metals in surface water exceed chronic ambient water quality criteria at least some of the time in all CSM Units and Segments for which data are available, except for Canyon Creek, Segment 01. Table 4.1.1.1-1 shows the CSM Units and Segments where ambient water quality criteria are not exceeded [HQ<1], or do not exceed the ambient water quality criteria by more than 10-fold [HQ<10]). Concentrations of copper exceed the chronic ambient water quality criteria by a factor of 10 (HQ > 10) only in CSM Unit 1, Upper South Fork Segment 01, and there only 2 percent of the time. In contrast, concentrations of cadmium exceed the ambient water quality criteria by factors of 10 or more in over 50 percent of the samples from Canyon Creek, Segment 5 and Ninemile Creek, Segments 02 and 04 in CSM Unit 1, and in Segment 02 of CSM Unit 2 (the South Fork in the Bunker Hill Superfund Site) (Figure 4.1.1.1-2). Concentrations of zinc exceed the ambient water quality criteria by factors of 10 or more in over 80 percent of the samples from the same three Segments. Other Segments with frequent exceedances of the ambient water quality criteria are Canyon Creek, Segment 04; Pine Creek, Segment 01; CSM Unit 2, Segment 01 (The South Fork from Canyon Creek to Elizabeth Park), and tributaries to the South Fork in the Bunker Hill Superfund Site (SEGSMLTR in Figure 4.1.1.1-2). [This text will be modified after the excluded data from the box are added to the analysis.]

Population studies of fish in particular, and benthic invertebrates to a lesser extent, support the effects predicted by the exceedances of the ambient water quality criteria and the site-specific toxicity testing in that the same CSM Segments rank most severely affected using all three lines of evidence.

Table 4.2.1-1 summarizes the lines of evidence for the aquatic receptors, and also indicates which CSM Segments have evidence of each type. The lines of evidence tributary streams in CSM Unit 1 generally do not include data on concentrations of metals in sediment, as samples collected were generally either sub-surface samples, or collected outside the wetted perimeter of streams. In tributaries where riparian soils are contaminated (Table XX) concentrations of metals in fine-grained sediments are thought to be similar to those in riparian soil.

The weight of evidence summary (Table 4.2.1-1) indicates risk based on metals in water in the lower North Fork of the Coeur d'Alene River (CSM Unit 2. MidGradSeg03). The causes for the indication of risk are hazard quotients greater than one based on the chronic natioal abiient water quality criteria and concentrations of dissolved cadmium, copper, lead, and zinc (Table 4.1.1.1-3) The North Fork is not thought to be affected by mining wastes and metals were not detected frequently in samples from the North Fork (Appendix I). The indicated hazard quotients greater than one are primarily based on calculation using one-half of detection limits that were more than twice the ambient water quality criteria (Table 4.1.1.1-4). Similarly, risks are indicated for Ninemile Creek Segment 03, also generally considered to be relatively unaffected by mining wastes. In the case of Ninemile Creek Segment 03, a single hazard quotient of 2.8 for lead, based on a non-detected lead result, caused the indication of hazard. For most of the remaining segments where risks are indicated, and for all of the segments where site-specific toxicity testing or biological surveys indicate risks (Table 4.2.1-1), hazard quotients are based on detected concentrations of metals (Table 4.1.1.1-4), and frequently exceeded ten (Table 4.1.1.1.1-2).

Water-quality data from the Spokane River provided by the State of Washington were not included in the preceding summaries. Independent analyses by the State of Washington (Hopkins and Johnson, 1997: Pelletier, 1999) have shown that State of Washington water-quality standards, which are equivalent to the national ambient water quality criteria, are commonly exceeded in the Washington portion of the Spokane River. Pelletier (1999) observed that chronic standards for zinc are exceeded during both low and high flows, but that dissolved lead and cadmium exceeded the chronic criteria infrequently, and only during higher flows. Dissolved copper generally does not exceed the Washington standards for chronic exposure in the Washington portion of the Spokane River. Hopkins and Johnson (1997) noted that during unusually high flows in 1997, concentrations of dissolved lead and zinc exceeded the State standards as far downstream as Long Lake, but by decreasing amounts downstream.

4.2.2 Benthic Invertebrates [Section deleted]

→ why deleted?
no risk description?

4.2.3 Aquatic Plants [Section deleted]

4.2.4 Amphibians

Three lines of evidence were available to evaluate risks to amphibians in the Coeur d'Alene River basin: single-chemical toxicity data, site-specific ambient media toxicity tests, and biological surveys. Although four species were identified as amphibian receptors (i.e., spotted frogs, Idaho giant, Coeur d'Alene, and long-toed salamanders; see Section 2.5.3), data specific to selected receptor species were only available for the spotted frog (i.e., analyses by Lefort et al. 1998). Consequently data for other amphibian species have been used to determine risks to the selected receptor species. Further, three of the four receptor species (e.g., spotted frogs, Idaho giant, and Coeur d'Alene salamanders) are speicies of concern and are therefore evaluated at the individual level; the remaining species, long-toed salamanders, are evaluated ath eht less stringent population level. A summary of the weight-of-evidence evaluation for amphibian receptors for the Coeur d'Alene River basin is presented in Table 4.2.4-1.

4.2.5 Terrestrial Plants

A summary of the weight-of-evidence evaluation for terrestrial plants in the Coeur d'Alene River basin is presented in Table 4.2.5-1.

4.2.6 Soil Invertebrates

A summary of the weight-of-evidence evaluation for soil invertebrates in the Coeur d'Alene River basin is presented in Table 4.2.6-1.

4.2.7 Microbial Processes

A summary of the weight-of-evidence evaluation for soil microbial processes in the Coeur d'Alene River basin is presented in Table 4.2.6-1.

4.2.8 Birds

A summary of the weight-of-evidence evaluation for avian receptors for the Coeur d'Alene River basin is presented in Table 4.2.8-1.

4.2.9 Mammals

A summary of the weight-of-evidence evaluation for mammalian receptors fo rthe Coeur d'Alene River basin is presented in Table 4.2.9-1.

4.2.10 Summary of Risk Characterization by Location and Habitat Type

To be added in the next draft.

4.3 UNCERTAINTY ANALYSIS

4.3.1 Problem Formulation

[[To be completed]]

4.3.2 Analysis

4.3.2.1 Exposure Characterization

4.3.2.1.1 Bank Stability

Exposure of aquatic receptors to bank instability is difficult to assess directly. As discussed, bank instability is part of a suite of interrelated physical factors that constitute risk, including increasing levels of substrate fines, bedload instability, loss of large woody debris recruitment, and increasing stream temperatures, in addition to the simplification of habitat structure and loss of suitable habitats. Some aquatic receptors may be able to compensate for degraded habitat conditions through behavioral adaptation (i.e., moving to more favorable locations). The degree to which receptors in a given CSM segment are exposed to the detrimental effects of bank instability depends on the level of bank instability present and the spatial distribution of favorable and unfavorable habitats. Therefore, assessing the ecological exposure of receptors to bank instability depends on an accurate accounting of the degree of bank instability present. Issues with representativeness of data are discussed in Section 4.3.2.2.1.

4.3.2.1.2 Substrate Composition and Mobility

Exposure of aquatic receptors to the detrimental effects of degraded substrate composition and mobility conditions is difficult to assess directly. As discussed in earlier sections, degradation of these characteristics can constitute risks to aquatic receptors through a number of pathways. The degree to which receptors in a given CSM segment are exposed to the detrimental effects of degraded substrate composition and increased bedload mobility is dependent on the degree to which conditions are degraded and the spatial distribution of favorable and unfavorable habitats. Further, some aquatic receptors may be able to compensate for degraded habitat conditions through behavioral adaptation (e.g., by moving to more favorable locations). Therefore, the ability to evaluate potential risks depends on the representativeness of the available data. Issues with representativeness of data are discussed below in Section 4.3.2.2.2.

4.3.2.1.3 Water Temperature

There are two categories of uncertainty regarding risk characterization for the temperature measure: structural limitations of data provided for the analysis, and spatial and temporal distribution of monitoring locations and events.

The temperature data used in this analysis were the result of continuous temperature monitoring, and are therefore representative of the true maximum temperatures recorded at given monitoring locations. The data provided for this analysis were summarized to show the high and average temperatures at a given location by month, as shown in Tables F-3.1.1.2.2.3-1 to -6 in Appendix F (Stratus 1999a, 1999b). This data structure does not allow for evaluation of the length of time that temperatures exceed critical thresholds, or the degree of diurnal temperature fluctuation that could reduce thermal stress on aquatic receptors. For example, cutthroat trout can tolerate brief periods with stream temperatures in excess of 26°C if considerable nighttime cooling takes place, but will not persist in areas where stream temperatures regularly exceed 22°C (Hickman and Raleigh 1982). These limitations may contribute to an overestimation of risk from high stream temperatures.

The spatial distribution of monitoring locations also contributes to uncertainty in characterizing risks from stream temperatures. In general, monitoring locations were selected to be representative of stream conditions in the area, suggesting that temperature data accurately captured conditions in a given area of a segment (Reiser 1999). However, the number and distribution of temperature monitoring locations were somewhat limited, particularly in tributary watersheds that were limited to one location each, in downstream segments near their mouths. It is not possible to determine from these data the spatial extent of stream temperatures that may exceed risk criteria. If high stream temperatures were limited to a small area of a segment, then extrapolating that temperature to the segment as a whole could result in an overestimation of risk.

A broader perspective on temperature conditions is desirable for evaluating the temperature measure. For example, the extent of diurnal temperature fluctuations during high temperature periods, and the period of time during which temperatures exceed critical thresholds would provide a better measure of thermal stress to receptors. However, the data provided in electronic form for this analysis were limited to the monthly averages and highs described. Continuous temperature monitoring was conducted for only 3 years during warm weather months. This is a relatively limited data set to evaluate risks from high temperatures. The 1994 monitoring period included the warmest recorded temperatures, but the data were limited to relatively few monitoring locations and only two suitable reference streams. Temperatures in the Little North Fork Coeur d'Alene River reached levels corresponding to a moderate risk to aquatic receptors, suggesting that risk criteria may overlap temperatures observed under extremely warm conditions. This suggests that risk criteria may be set too low, resulting in an overestimation of risk. However, the distribution of temperatures in reference streams in the remaining monitoring years supports the risk criteria as defined. Conversely, the 1994 data also suggest that risks to aquatic receptors from high stream temperatures may be underestimated in segments lacking data for 1994, and that a broader time series of data is required to appropriately evaluate the temperature measure.

4.3.2.1.4 [Section deleted]

4.3.2.1.5 Habitat Suitability Index Model for the Riparian Habitat

The number and geographic distribution of vegetative sampling sites were limited in certain parts of the basin. For example, the East Fork Ninemile Creek had five sampling sites located just upgradient from the confluence with the main stem of Ninemile Creek. Data from these five sampling sites were used to represent the riparian vegetation for NMSeg02, which extends approximately 2.5 stream miles upgradient of the sampling sites, and NMSeg04, which extends approximately 3.1 stream miles downgradient from the sampling sites. Although the statistical design for the upper basin was based on a stratified random sample, the representativeness of sampling locations for defining the condition of segments in this risk assessment is uncertain. The direction and magnitude of the uncertainty associated with field sampling is unknown.

Field data to support the riparian HSI were collected in 1994. Activities have occurred in the basin since that time that may affect the conclusions based on the 1994 data. Removal actions and habitat restoration activities have taken place at several locations (e.g., NMSeg02 and CCSeg05) that may confound interpretation of HSI results. Field observations following restoration activities showed that high flows have impacted many of the constructed features, and survival of riparian plantings is low (Heinle 1999).

4.3.2.1.6 Suspended Solids

Suspended solids measurements are indicative of concentrations at a discrete location and point in time. Given the limited number of suspended solids measurements available for some locations within the Coeur d'Alene River drainage, the duration of exposure to elevated concentrations of suspended solids is unknown. This unknown exposure duration limits the accuracy of risk estimates to aquatic species. Although not attempted within this risk assessment, it may be possible to estimate suspended solids concentrations, and subsequently risks, at locations within the lower Coeur d'Alene River at two locations: Rose Lake and Harrison. This is because the USGS has developed linear regressions relating suspended solids discharge (in units of tons/day) and stream discharge (in units of cubic feet/second). If stream discharge were converted to a volume of water per day, the measured mass of suspended solids discharge per day could easily be converted into a concentration per unit volume (such as mg/L) by dividing the mass of solids discharged by the volume of water discharged once the discharged mass and volume are converted into appropriate units. Daily discharge records are available from both the USGS Rose Lake and Harrison monitoring stations, so the complete range of suspended solids concentrations over the period of record for the stations could be estimated. Risks associated with the estimated range of suspended solids could also be calculated. Given the range of measured suspended solids concentrations (collected during discharge events as diverse as summer low flows and the second largest flood on record for the river) upon which risks were actually calculated, it is unlikely that the concentration range of suspended solids would change appreciably from that used in this risk assessment. What would be improved is the estimate of duration of exposure to the suspended solids concentrations in the river.

As noted in Section 3.1.1.2.2.6, the highest recorded suspended solids concentrations occurred during the extreme flood events of early 1996. The only suspended solids concentrations that exceeded 100 mg/L were recorded on February 9 and 10 at Cataldo (LCDRSeg01), February 9 at Rose Lake (LCDRseg02), and February 8 and 10 at Harrison (LCDRSeg05). No comparable data were collected at the St. Joe River reference site at Calder during that period. Since a comparable reference area data set is not available, it is possible that risks may be overestimated in the assessment segments.

4.3.2.1.7 [Section deleted]

4.3.2.1.8 Sediment Deposition Rate

Compaction is a natural process that occurs when newer layers of sediment are deposited on previously deposited sediment layers, forcing water out of the interstitial spaces between sediment particles. This results in a compression of deeper sediments relative to the more recently deposited shallow sediments. None of the studies that estimated sediment deposition rates in the Coeur d'Alene River basin quantified compaction. To the extent that the deeper sediments compacted, sediment deposition rates are underestimated. The deposition rate measure is based on estimated deposition rates from relatively few cores. Although this is because relatively few cores from the Coeur d'Alene River basin were analyzed for temporal chronologies (such analysis is required before calculating deposition rate), it results in uncertainty in the sediment deposition rate measures, as they are based on a small number of samples. The lack of well-defined reference areas for CSM Units 3 and 4 also contributes to uncertainty about deposition rate measure.

4.3.2.1.9 Spatial Distribution and Connectivity

The exposure of riverine and riparian receptors to the risks described by the spatial distribution and connectivity measure is a product of their exposure to the risks expressed by the lower hierarchy measures of ecosystem and receptor characteristics described previously. Consequently, the uncertainty involved in evaluating exposure to degraded spatial distribution is a product of the uncertainties in exposure characterization for each of those lower hierarchy measures. The lower hierarchy measures attempt to capture the degree to which conditions characterized by the measure are degraded and the spatial distribution of favorable and unfavorable habitats at the segment level. The spatial distribution and connectivity measure extends this examination beyond the segment scale to examine the risks posed by spatially extensive habitat degradation. Therefore, uncertainty exists in the degree of exposure to the detrimental effects of degraded spatial distribution and connectivity. The degree of uncertainty is dependent on how accurately the data characterizing each of the lower hierarchy measures captures the degree to which conditions are degraded in a segment, and the spatial distribution of favorable and unfavorable habitats. The assumption applied is that the habitat data used to characterize the lower hierarchy measures of ecosystem and receptor characteristics provide an accurate representation of conditions at the segment level. That is to say, that the habitat data used to characterize these measures are indicative of conditions across distances ranging from thousands of feet to miles, versus shorter distances. This assumption is supported by the assertion that the habitat survey locations selected are representative of conditions across broader stream and riparian areas (IDEQ 1998; LeJeune and Cacaela 1998; Reiser 1999), and conditions observed in the field and in aerial photographs (URSG and CH2MHILL 1999).

The additive uncertainty in exposure characterization for the lower hierarchy measures contributes to uncertainty in characterizing exposure to degraded spatial distribution and connectivity. As an example, in riverine habitats refuge areas may exist that are not captured by the data used to characterize the lower hierarchy measures, which create linkages between reaches with relatively good favorable conditions. Further, favorable habitat conditions may exist for part of the year, creating refuges not captured in the limited time series of data available for this analysis or accurately represented in the data structure. Temporal windows of favorable habitat conditions could overlap favorably with the life history characteristics of aquatic receptors, limiting the detrimental effects of exposure to otherwise degraded conditions.

4.3.2.1.10 Riparian Vegetation

The number and geographic distribution of riparian vegetative sampling sites generated as part of the NRDA (Hagler Bailly 1995) were limited in certain parts of the basin (Figure 3.1.1.2.2.10-1). For example, the East Fork Ninemile Creek has five sampling sites just upgradient of the confluence with main stem Ninemile Creek. Data from these five sampling sites were used to represent the riparian vegetation for NMSeg02, which extends approximately 2.5 river miles upgradient of the sampling sites and NMSeg04, which extends approximately 3.1 river miles downgradient from the sampling sites. Although a stratified random sampling design was used in the upper basin, the representativeness of sampling locations for defining the condition of CSM segments in this risk assessment is uncertain. The direction and magnitude of the uncertainty associated with field sampling design is unknown.

For this risk assessment, vegetation and soil characteristics data from reference areas on Ninemile Creek, Canyon Creek, and the Little North Fork of the Coeur d'Alene River were pooled for making statistical comparisons to data from assessment segments in CSM Units 1 and 2. Pooling of the reference data was justified because there were no statistically significant differences between the vegetative characteristics found in sampling locations on the Little North Fork compared to reference areas in Ninemile and Canyon Creeks. These reference areas are characterized by different geomorphologic and hydrologic characteristics that may raise the question of ecological relevance for pooling the data. However, the differences between the assessment segments with degraded riparian vegetation and the reference areas were so striking that conclusions would be the same no matter how the reference area data were grouped.

The riparian vegetation field data gathered as part of the NRDA (Hagler Bailly 1995) were collected in 1994. Since that time removal actions and habitat restoration activities have taken place at several locations (e.g., NMSeg02 and CCSeg05) that may confound interpretation of riparian vegetation analysis results. Field observations following restoration activities showed that high flows have impacted many of the constructed features and survival of riparian plantings is low (Heinle 1999).

4.3.2.2 Ecological Effects Characterization

4.3.2.2.1 Bank Stability, CSM Units 1 and 2 (Excluding MidGradSeg04)

The habitat data used to describe the bank stability measure were collected using qualitative survey techniques. These survey techniques employ established criteria for rating bank stability and other habitat characteristics (Barbour et al. 1997; Pfankuch 1978). However, the potential for over- and under-representation of bank stability exists. Further, the habitat surveys were conducted at a limited number of sampling sites, often only one or two locations in a given CSM segment. The survey locations were selected to be representative of conditions throughout the drainage or watershed, and thereby representative of the CSM segments in which they were conducted (Reiser 1999; IDEQ 1998). Bank stability in CSM Unit 3 and MidGradSeg04 was also assessed qualitatively, but inventoried over the entire length of all segments, so estimates of bank instability in these segments are expected to be representative of actual conditions (Wesche 1999).

It is important to note that in general, the intent of the qualitative characteristics used to describe bank stability is to provide an estimate of the degree of stability provided by natural ecosystem functions. However, in some cases characteristics scores may reflect un-natural conditions. As an example, channelization and removal of erodable materials from floodplains and riparian areas in Canyon Creek has left behind large, relatively stable substrate. In such areas, high scores for bank stability may not necessarily equate to ecologically desirable conditions.

As discussed in Section 2.4.3.3, bank stability is one expression of a suite of interrelated physical conditions in montane river systems. Bank instability and substrate composition and mobility are intimately linked, and degraded conditions in one of these measures will often accompany degraded conditions in the other. Given this relationship, the characteristics used to describe these measures often reflect the same phenomena: morphological adjustment of the stream channel to changes in basin hydrology, large-scale bedload inputs, or other forms of watershed level degradation. The bank stability measure is still viewed independently; however, as it is an important indicator of habitat characteristics for aquatic receptors.

Reference areas used in the riparian vegetation analysis were selected based upon the presumed lack of impact from mining-related hazardous waste. As previously noted, the Canyon Creek reference area did show some signs that it was exposed to mining-related wastes. Therefore, it is possible that inclusion of the reference data from CCSeg02 may have biased comparisons to enhance the likelihood of making a Type II error (erroneously concluding there was no significant difference between assessment and reference areas).

4.3.2.2.2 Bank Stability, CSM Unit 3 and MidGradSeg04

A defensible method for characterizing ecological effects and analyzing physical stressor response and condition could not be developed due to lack of available data for a comparable reference area. Data on bank stability in MidGradSeg04 and CSM Unit 3 are summarized and presented by CSM segment in Section 3.1.1.2.2.1. The reasoning for not characterizing risks in these segments, and the methods for summarizing data on bank stability, are discussed below.

The main stem Coeur d'Alene River from the confluence of the North Fork and South Fork to Coeur d'Alene Lake is a Rosgen Type E stream channel, which conforms to the characteristics of a montane floodplain and montane transition river continuum (Rosgen 1994; Stanford et al. 1996). This portion of the river has been modified for flood control purposes, transportation, and residential and agricultural development. The hydrologic characteristics of this portion of the river have also been altered by the construction and operation of Post Falls dam on the Spokane River. A suitable reference area was not identified for the main stem Coeur d'Alene River during the Ecological Restoration Planning Workshop conducted as part of the NRDA process (Hagler Bailly 1998). The lower reaches of the St. Joe River have some characteristics in common with the main stem Coeur d'Alene River; however, no source of comparable data on bank stability conditions has been identified for this area.

Bank instability, in conjunction with channel migration, is part of a natural disturbance regime that contributes to the diversity and renewal of habitat types in river systems of this type that have not been substantially modified by human activities. The natural patterns of disturbance and recovery can be altered by various forms of anthropogenic disturbance, resulting in increased bank instability and channel adjustment (Naiman et al. 1992a, 1992b; Stanford et al. 1996; Gore and Shields 1995; Ward and Stanford 1995). In the main stem Coeur d'Alene River, the natural pattern of bank stability, disturbance, and channel migration has been disrupted by large inputs of bedload and changes in watershed hydrology from upstream land uses, alteration of the hydrologic gradient of the system due to downstream flow regulation, and river and floodplain modification. These anthropogenic impacts, in conjunction with other factors, have resulted in a disequilibrium in bank stability characteristics in the main stem Coeur d'Alene River and ongoing, system-wide bank failure. Bank instability, erosion, and the resulting aggradation and degradation of the river channel have resulted in degradation of riverine habitat quality in the main stem Coeur d'Alene River (Wesche 1999). Despite the fact that extensive bank instability has been inventoried in MidGradSeg04 and CSM Unit 3, a comparable reference area was not available to develop a scale of bank erosion impacts against which to develop thresholds for risk to aquatic receptors. Therefore, risks associated with bank instability in MidGradSeg04 and CSM Unit 3 cannot be evaluated at this time.

4.3.2.2.3 Substrate Composition and Mobility

There are two categories of uncertainty in the characterization of risk to aquatic receptors from substrate composition and mobility. The first category of uncertainty involves the qualitative nature of the habitat data, the distribution of survey locations within a segment, and their representativeness of segment level conditions. The second category of uncertainty results from the inability to determine the degree of degraded substrate composition and mobility conditions

Imbalance in view

directly attributable to mining-related hazardous substances, versus other forms of natural and anthropogenic disturbance.

The habitat data used to describe the substrate composition and mobility measure, with the exception of R2 data on substrate fines, were collected using qualitative survey techniques. (R2 Resources sampled quantitatively for substrate fines in selected locations using standardized laboratory techniques [R2 Resource Consultants 1995].) The qualitative survey techniques employ established criteria for rating elements of substrate composition and mobility, along with other habitat characteristics (Barbour et al. 1997; Pfankuch 1978). However, the potential for over- and under-representation of these characteristics exists through observer bias and other factors. Further, the habitat surveys were conducted at a limited number of sampling sites, often only one or two locations, and in only one or two years in a given CSM segment. The survey locations were selected to be representative of conditions throughout the drainage or watershed, and thereby representative of the CSM segments in which they were conducted (Reiser 1999). However, given the limited number of sampling sites, and the fact that interannual variability is not well represented in the data set, additional potential exists for over- or under-representation of actual conditions for substrate composition and mobility. Further, the results of both RBP and the SRI protocols depend on recent flow history and may therefore not capture evidence of degraded substrate composition and mobility due to the timing of surveys at the end of the summer low flow period. This indicates that degraded conditions may be under-represented by the chosen characteristics, leading to underestimation of risks to aquatic receptors.

Another issue influencing risk characterization is the disparity between observed geomorphic stability and the stability of biologically important substrate and other critical habitat features. Armored channels (substrate degraded down to cobble- and boulder-sized substrate) with simplified channel structure and high stream energies will generally have a low percentage of substrate fines and little or no evidence of bedload mobility. However, such channels will lack the habitat structure and diversity of substrate sizes (particularly gravel- to pebble-sized substrate smaller than 3 inches in diameter) necessary to support salmonid populations and a diverse macroinvertebrate community. It is not known if the scouring and deposition characteristics used in this analysis distinguished these types of stability. Ideally the substrate size distribution and percent stable characteristic would capture the lack of biologically important substrate under these conditions. However, there is uncertainty here due to the subjective basis for scoring this characteristic based on experience-based comparison to "normal conditions" for streams in this area and the considerable history of habitat degradation due to anthropogenic activities. These factors contribute to the potential to underestimate risks to aquatic receptors from degraded substrate composition and mobility characteristics.

As with the bank stability measure, numerous forms of anthropogenic and natural disturbance can potentially combine with the impacts of mining-related hazardous waste to have synergistic effects on substrate composition and mobility throughout the Coeur d'Alene River basin. Even with detailed quantitative data on substrate composition and mobility~~, it would not be possible~~ to attribute a proportion of detrimental impacts to any given stressor. Therefore, the habitat data ~~used in the risk characterization include the impacts of all~~ these stressors on this measure, meaning that mining-related hazardous substances are just one contributing factor to risks to aquatic receptors from degradation of substrate composition and mobility.

4.3.2.2.4 Water Temperature

There are three categories of uncertainty in the characterization of risks to aquatic receptors from high stream temperatures. The first category of uncertainty involves the potential for underestimating risks to some aquatic receptors through use of the cutthroat trout temperature tolerance range as a proxy for all aquatic species. The second category of uncertainty evolves from the fact that risk criteria based solely on temperature do not reflect the capacity for some species, particularly salmonids, to respond behaviorally to unfavorable temperatures. The final category of uncertainty results from the inability to determine the degree to which degraded temperature conditions can be directly attributed to the detrimental effects of mining-related hazardous substances versus other natural and anthropogenic disturbances.

As discussed in Section 3.2.2.3, the rationale for using cutthroat trout temperature tolerance as a proxy for the tolerance ranges of other aquatic species in CSM Units 1 and 2 is that cutthroat are a keystone native species in watersheds of the Northern Rocky Mountains Ecoregion (Maret 1995; Maret et al. 1997; Omernick and Gallant 1986). Therefore, the temperature range supporting this species is believed to be generally representative of those for other aquatic species in these ecosystems. In making this assumption, it is recognized that several species of concern, including bull trout, some species of sculpins and amphibians, and some macroinvertebrates, have lower tolerance ranges than cutthroat trout. However, the spatial and temporal distribution of habitats used by these species in relation to temperature monitoring locations and timing is not established, so exposure of these receptors to high stream temperatures is uncertain. Further, the risk criteria established for cutthroat trout incorporate temperatures observed in suitable reference streams, which ideally reflect stream temperatures in the region under less disturbed conditions. Therefore, cutthroat trout risk criteria are used as proxy values for other aquatic receptors with the understanding that risks to these species may be underestimated.

The risk criteria established for cutthroat trout do not reflect the ability of some fish species, particularly salmonids, to respond behaviorally to unfavorable temperature conditions. Cutthroat and bull trout are capable of migrating out of stream reaches with unfavorable temperatures. Other fish species (e.g., sculpins), amphibians, and macroinvertebrates are not capable of such behavioral adaptation, however, and will continue to be exposed. Even if salmonids are capable of migrating out of high risk segments, the loss of use of what may be important habitat for a life history stage still constitutes a risk, an issue addressed in Section 3.2.2.9. Further, temperature monitoring data do not reflect the full profile of stream temperatures in microhabitats within a stream segment. Trout, sculpin, and other fish species can retreat to deep pools and cooler waters when stream temperatures reach unfavorable levels. If these habitats are readily available in a stream segment with otherwise high temperatures, this could result in an overestimation of risk for that segment. It is useful to note, however, that there is overlap between segments with high stream temperatures and otherwise degraded habitat conditions, suggesting that opportunities for behavioral adaptation are limited in segments with high stream temperatures. In contrast, macroinvertebrate receptors are constrained by their habitat requirements and limited mobility; thus their ability to respond to unfavorable temperatures is limited and they are more susceptible to temperature impacts than other fauna. As discussed, the ability of receptors to respond behaviorally to high stream temperatures by moving to refuge areas may result in overestimation of risk.

Degraded stream temperature conditions are the typical result of degraded physical conditions in the watershed. Numerous anthropogenic and natural disturbances potentially combined with the impacts of mining-related hazardous waste, can result in synergistic effects on the morphology and hydrology of riverine habitat in the Coeur d'Alene River basin. ~~As noted in discussion of~~ other measures of ecosystem and aquatic receptor characteristics, it would not be possible to isolate the detrimental impacts of a given stressor ~~from any other~~ stressor. Therefore, the data used to characterize risks for the temperature ~~measure reflect the impacts of numerous physical stressors on riverine~~ habitat structure. While it can be asserted with confidence that mining-related hazardous substances have had detrimental impacts on stream temperature conditions in CSM Units 1 and 2, it is not possible to ascribe a degree of impact from this stressor versus other sources of disturbance.

negates the impacts of mining wastes

4.3.2.2.5 Habitat Suitability Index Model for the Riparian Habitat

Reference areas used in the HSI analysis were selected based upon their presumed lack of impact from mining-related hazardous waste. As previously noted, the Canyon Creek reference area showed signs of being exposed to mining-related wastes. Although a comparison of riparian vegetative characteristics (Appendix E) showed that the Canyon Creek reference area (CCSeg02) was not significantly different from the Ninemile (NMSeg03) and Little North Fork reference areas, the mean HSI for CCSeg02 was 0.14, compared to 0.73 for NMSeg03 and 0.68 for the Little North Fork. Therefore, it is possible that inclusion of the reference data from CCSeg02 may have biased comparisons and enhanced the likelihood of making a Type II error (erroneously concluding there is no significant difference among sites).

Riparian vegetation quality and the associated HSI were relatively high within CSM Unit 3. There is considerably less urban development in CSM Unit 3 compared to CSM Units 1 and 2. Agriculture is practiced on roughly 10,000 acres within the floodplain. In addition, the hydrology of the lower Coeur d'Alene River and its floodplain has been highly modified through the creation of Post Falls dam and diking, channelization, and shoreline development. These alterations have disrupted the natural meander patterns of the river and fragmented the hydraulic connectivity between the river and lateral lakes and wetlands.

HSI data from the riparian resources injury assessment (Hagler Bailly 1995) were available for LCDRSeg01, LCDRSeg02, LCDRSeg03, LCDRSeg04, and LCDRSeg05.

4.3.2.2.6 Suspended Solids

Most measured suspended solids concentrations used in this risk assessment are less than 10 mg/L, including all available records from both the St. Joe River reference area and the Spokane River at Post Falls dam. A review of the appendix in Newcombe and Jensen (1996) shows that relatively few of the records used to derive the regressions of severity of effect with suspended solids concentration and exposure duration are for suspended solids concentrations lower than 10 mg/L. A commonly asserted caution regarding the application of statistical regression models is that the models should not be used to make predictions of dependent variables (severity of effect in this case) outside of the range of values of independent variables (suspended solids concentration and exposure duration in this case) used in the regression (Zar 1996). Although this statistical guidance was not violated during the application of the regression equations in this risk assessment, the relative lack of data for concentrations below 10 mg/L used during the development of the regressions leads to uncertainty regarding the accuracy of the severity of effect and risk estimates for waters containing low concentrations of suspended solids. One reason for this uncertainty is that at low concentrations, the relationship between concentration/exposure duration and severity of effect may be curvilinear, not linear as was assumed by Newcombe and Jensen (1996). This uncertainty cannot be quantified either as to magnitude or direction; i.e., both the accuracy of the regression model predictions and whether they over- or underestimate risks is unknown.

Newcombe and Jensen (1996) do provide coefficient of determination values for their regressions, which permit an evaluation of the proportion of the total variation in severity of adverse effects accounted for by variation in suspended solids concentration and exposure duration. For the regressions for juvenile and adult salmonids, eggs and larvae of salmonids and nonsalmonids, and adult nonsalmonids, variation in concentration and exposure duration account for 60 percent, 55 percent and 70 percent, respectively, of the variation in severity of effect. All three regressions are statistically significant at the $P < 0.01$ significance level. Overall, the regressions appear to provide a valid estimate of the severity of adverse effect to fish from exposure to suspended solids. What the regressions cannot take into account is the ability of fish, and to a lesser extent aquatic macroinvertebrates, to avoid water with high suspended solids levels in favor of water with lower suspended solids concentrations. Although the data are not available to make a quantitative statement, it is likely that the lateral lakes of the main stem Coeur d'Alene River have different, and possibly at times lower, suspended solids concentrations. If so, they can serve as refugia for species attempting to avoid elevated concentrations of suspended solids in the main stem Coeur d'Alene River. To the extent that species utilize the lateral lakes as refugia and are exposed to lower concentrations of suspended solids, risks are overestimated.

As noted in Section 3.2.2.6, the risk estimates from the Newcombe and Jensen (1996) regressions are for groups of receptors, such as juvenile and adult salmonids. This means that risks to individual species may be greater than or less than the estimated risks, depending on the sensitivity of individual species to suspended solids.

4.3.2.2.7 Sediment Deposition Rate

Although elevated sedimentation rates are known to have adverse impacts on benthic biota, none of the studies where this has been documented have been performed in the Coeur d'Alene River basin. The estimates of sediment deposition rates that pose ecological risks to benthic species are based on a combination of literature values and increases in what sedimentation rates in the Coeur d'Alene River basin would be in the absence of mining activities. It is uncertain exactly how much of an increase in sediment deposition rate is needed to adversely affect aquatic species. Horowitz et al. (1993, 1995) note the lack of benthic biological activity in sediments in the vicinity of the Coeur d'Alene River delta, and specifically Cores 123, 8 and 9 (Table 3.1.1.2.2.8-1).

Horowitz et al. (1995) state that it is unknown whether the disappearance of benthic species resulted from increased turbidity and suspended solids in the water column, increased sediment deposition rates, or increased trace metal concentrations in the deposited sediments. What is known is that benthic populations are reduced or absent in portions of the Coeur d'Alene River delta and Coeur d'Alene Lake with elevated sediment deposition rates. Hoiland et al. (1994) noted that benthic invertebrate taxa richness is reduced in the main stem Coeur d'Alene River relative to that of the North Fork Coeur d'Alene River. Ruud (1996) noted differences in the dominant benthic taxa of Coeur d'Alene Lake and his reference area, Priest Lake. Lenat et al. (1981) summarized the impact of increased sediment deposition on benthic macroinvertebrates as follows: small increases in sediment deposition serve to decrease density and standing stock of the benthos, but without altering community structure or species richness. Higher sediment deposition rates can alter substrate types, which results in changes in the numbers and types of species present; alter community structure and species diversity; and may result in increased population densities of the remaining species. The two impacts of increased sediment deposition described by Lenat et al. (1981) can also be described as habitat alteration resulting from small increases in deposited, fine-grained sediment reducing interstitial habitat, and habitat change that results from greater increases in deposited sediment that are sufficient to change the predominant bottom substrate type. When combined with literature indicating that increases in sediment deposition rates as low as 0.1 cm/yr can result in altered benthic macroinvertebrate communities (Minshall 1984) and the observed differences in benthic communities in Coeur d'Alene Lake (Ruud 1996) and the main stem Coeur d'Alene River (Hoiland et al. 1994) relative to reference areas, the hypothesis that increased sediment deposition rates in the Coeur d'Alene River basin is associated with altered benthic communities is supported.

4.3.2.2.8 Spatial Distribution of Stream Reaches and Riparian Habitats with Acceptable Physical Conditions (Spatial Distribution and Connectivity)

As with the lower hierarchy measures of ecosystem and receptor characteristics, there are two categories of uncertainty involved in characterizing the risks to aquatic and riparian receptors from degraded spatial distribution and connectivity. The first category of uncertainty involves the qualitative nature of the habitat data, and the distribution of survey locations within segments and their representativeness of segment level conditions. The second category of uncertainty results from the inability to determine the degree to which degraded conditions are directly attributable to mining-related hazardous substances, versus other forms of natural and anthropogenic disturbance. The uncertainty in ecological effects characterization for the spatial distribution and connectivity measure is the product of uncertainties for the lower hierarchy measures of ecosystem and receptor characteristics. Uncertainty for these measures has been described above.

4.3.3 Risk Characterization

4.3.3.1 Risk Estimation

4.3.3.1.1 Chemical

4.3.3.1.2 Riparian Vegetation

The analyses of relationships between vegetative and soil characteristics had several statistical limitations. Many of the soil characteristics covaried with each other and were not independent of each other. Multicollinearity increases the standard error of the regression coefficients. Furthermore, the cover characteristics for herbs, shrubs, and trees did not fit, nor could they be transformed to fit, a normal distribution and therefore failed the assumption of normality that is required in linear regression analysis. These statistical limitations reduce the reliability of the regression analyses, particularly for vegetative cover characteristics. Results of the regression analyses were used to demonstrate overall relationships between vegetative and soil characteristics and results may not be usable to predict the condition of the riparian vegetation with any degree of confidence.

Assessment segments on Ninemile Creek, Canyon Creek, and South Fork Coeur d'Alene River have been highly modified by urbanization and channelization. These levels of anthropogenic activity have themselves affected the riparian vegetation. Reference areas were similar to the assessment segments in terms of general geomorphology and hydrology, but did not have the same level of urbanization and channelization. Therefore, the contribution of soil-borne hazardous substances to the condition of the riparian vegetation in the field cannot be readily determined. Furthermore, this risk estimation was not intended to distinguish the effects of urbanization and channelization from the effects of hazardous substances on the riparian vegetation in the assessment segments in CSM Units 1 and 2.

losing site of what the mining wastes did to the basin

4.3.3.2 Risk Description

[[Need text.]]

5.0 Conclusions/
Remedial Action

SECTION 5.0 SUMMARY OF ECOLOGICAL STATUS RANKING

what about Cd?

5.1 CONCLUSIONS

Conclusions concerning ~~that~~ the nature and extent of ecological risks that COPECs present to receptors within the Coeur d'Alene River basin were drawn based on the weight-of-evidence analyses. The general conclusion is that heavy metals, primarily lead and zinc present significant ecological risks to most ecological receptors throughout the basin. Few receptors were identified for which no ecological risks are estimated. In all receptor classes, ecological risks from at least one COPEC in at least one area of the basin were identified. Because multiple lines of evidence were available for evaluation of risks for some receptors in all receptor classes (except soil invertebrates and soil microbial processes), the strength of many risk conclusions is considered to be high. Brief summaries of the available lines of evidence and risk conclusions for each receptor class are presented below.

5.1.1 Aquatic Receptors

Review of the available evidence of risks to aquatic receptors leads to the following conclusions:

- Exposure of aquatic organisms to metals has been confirmed by the presence of elevated concentrations of metals in the tissues of fish, invertebrates, and plants.

- Concentrations of metals in surface water exceed acute ambient water quality criteria by a factor of ten or more in more than 25 percent of samples collected from upper Beaver Creek, lower Canyon Creek, lower Ninemile Creek, The South Fork from Canyon Creek to Enaville, and in tributaries to the South Fork in the Bunker Hill Superfund site, indicating that exposure to waters in those areas is commonly lethal to some aquatic life.

- Toxicity testing using water from heavily contaminated portions of Canyon Creek and the South Fork of the Coeur d'Alene River indicated that substantial dilution with clean water (ten-fold, or more) is required to eliminate acute toxicity.

- Concentrations of metals exceed chronic ambient water quality criteria by a factor of 10 or more in over 50 percent of the samples from the same areas (except Beaver Creek), indicating that growth and reproduction of surviving aquatic life would be substantially reduced in the same areas.

- Site-specific toxicity testing and/or biological surveys indicate lethal effects of waters or reduced populations of aquatic life in the same areas, except for Beaver Creek where biological surveys were not done in areas with high metals concentrations.

- Concentrations of metals in water exceed chronic ambient water quality criteria by less than ten-fold in virtually all areas assessed that are downstream of sources

Spotted frogs	csm 1, ~~2~~ 3 (Cd, Pb, Zn),
Id Giant Salamander	csm 1, 2 (Cd, Pb, Zn)
CdA Salamander	csm 1, 2 (Cd, Pb, Zn)
long-toed salamander	csm 3 (sg 2, 3, 5 + 6) Cd + Zn
	csm 3 (sg 4) Cd

of mining waste indicating adverse effects on growth and reproduction of aquatic life in all CSM Units, and most CSM segments.

- Biological surveys in some areas with metals concentrations less than ten times the ambient water quality criteria (the Spokane River) have suggested that metals toxicity contributes to high mortality rates of trout.

- Toxic effects of contaminated sediment are believed to contribute to the adverse effects on aquatic life, but are more difficult to assess because chemical conditions are likely to cause variability in the bioavailability of metals in sediment.

- Physical disturbances caused by land management, and modifications of stream channels caused by construction of infrastructure, adversely affect the ability of streams in the Coeur d'Alene River basin to support aquatic organisms. Those factors were considered in part by using reference areas as a comparison when evaluating biological surveys and habitat conditions.

5.1.2 Amphibians

Up to three lines of evidence (single chemical toxicity data, ambient media toxicity tests, and biological surveys) were available to evaluate risks to amphibian receptors in the Coeur d'Alene River basin. Risks to health and survival from heavy metals are present for all four species of amphibian. Cadmium, lead, or zinc (singly or in combination) present risks to spotted frogs, Idaho giant salamanders, and Coeur d'Alene salamanders throughout most of CSM unit 1 (except for the Big and Pine Creek segments) and in CSM unit 2; cadmium, lead, or zinc also present risks to spotted frogs throughout CSM unit 3, cadmium and zinc, and cadmium only, present risks to the health and survival of long-toed salamanders in CSM unit 3, segments 2, 3, 5, and 6; and CSM unit 3, segment 4, respectively. COPECs do not present a risk to long-toed salamanders in CSM unit 3, segment 1, or within CSM units 4 or 5.

confusing discussion

5.1.3 Terrestrial Plants

— what about spotted frogs, Id Giant salamander & CdA salamander in CSM 4+5?

Up to three lines of evidence (single chemical toxicity data, ambient media toxicity tests, and biological surveys), were available to evaluate risks to terrestrial plants in the Coeur d'Alene River basin. Risks to health and survival from heavy metals are present for all six plant species considered and for the plant community in general. Arsenic, cadmium, lead and zinc present risks to all specific receptor species and the plant community in general in all segments of CSM units 1, 2, 3, and 5. Copper also presented a risk to all specific receptor species and the plant community in general in all segments and CSM units except for Big Creek in CSM 1 and in CSM 5.

No risk in CSM4

5.1.4 Soil Invertebrates

A single line of evidence, single chemical toxicity data, was available to evaluate risks to soil invertebrates in the Coeur d'Alene River basin. Copper, lead and zinc present risks to the soil invertebrate communities in all segments of CSM units 1, 2, 3, and 5. Cadmium presents a risk in Canyon Creek and UpSFCDRSeg01 in CSM 1, and in all segments of CSM units 2, 3, and 5. Arsenic presents a risk in Pine Creek and UpSFCDRSeg01 in CSM 1, and in all segments of CSM units 2 and 3.

5.1.5 Soil Microbial Processes

A single line of evidence, single chemical toxicity data, was available to evaluate risks to soil microbial processes in the Coeur d'Alene River basin. Lead and zinc present risks to the soil microbial processes in all segments of CSM units 1, 2, 3, and 5. Cadmium presents a risk in all segments of CSM units 1, 2, 3, and 5 except CSM unit 1 Pine Creek. Copper presents a risk in Ninemile Creek and UpSFCDRSeg01 in CSM 1, and in all segments of CSM units 2 and 3. Arsenic presents a risk only in CSM 3 segment 6.

5.1.6 Birds

Up to five lines of evidence (single chemical external exposure, single chemical internal exposure [blood], single chemical internal exposure [liver or kidney], ambient media toxicity tests, and biological surveys) were available to evaluate risks to avian receptors in the Coeur d'Alene River basin. Of the 24 avian receptors, data consisted of only a single line of evidence for 12. Two, three, four, and five lines of evidence were available for one, three, four, and four receptors, respectively. Risks to health and survival from at least one heavy metal in at least one area were identified for 23 of the 24 avian receptor species. The great horned owl is the only species for which no risks from heavy metals in the Coeur d'Alene River basin were identified. Lead, zinc, and cadmium present the greatest risks to birds in the Coeur d'Alene River basin. Not only do these metals present risks to the greatest number of species (23, 19, and 17, for lead, zinc, and cadmium, respectively), the magnitude of risks are also highest (HQs for lead and zinc exceeded 100 and cadmium exceeded 10 for some species in some locations). Risks from arsenic, copper, and mercury were comparatively much less; these COPECs were risk drivers for 5, 4, and 4 species for arsenic, copper and mercury, respectively. Spatially, significant risks from each of the six COPECs were identified in four of the five CSM units. Only in CSM 4 were risks identified for a single COPEC (Zn).

p 4-17 says zinc does not pose a risk to health + survival of mammals ?!?

5.1.7 Mammals

Although three lines of evidence (single chemical external exposure, single chemical internal exposure [liver or kidney], and biological surveys) were available to evaluate risks to mammalian receptors in the Coeur d'Alene River basin, at most two lines were available for any given receptor. Of the 18 mammalian receptors, data consisted of only a single line of evidence for 11. Two lines of evidence were available for seven receptors. Risks to health and survival from at least one heavy metal in at least one area were identified for 16 of the 18 mammalian receptor species. Fisher and lynx were the only species for which no risks from heavy metals were identified. Whereas risks to birds were dominated by specific COPECs (i.e., lead, zinc, and cadmium), no single COPEC stands out as a dominant risk driver for mammals. Zinc presented a risk to the greatest number of species (15) and cadmium the least (9). Arsenic, copper, lead and mercury pose risks to 13, 11, 10, and 12 species, respectively. Spatially, significant risks from each of the six COPECs were identified in four of the five CSM units. Only in CSM 4 were risks

A. need to establish right #5

B. conclusions contrary to expert report

add qualifying language

Isn't this odd since Beaver Crk has v. high metals in the water?

identified for a single COPEC (Zn). No risks to any mammalian receptors were identified in Beaver and Pritchard Creeks in CSM unit 1.

5.2 ECOLOGICAL REMEDIAL ACTION OBJECTIVES

5.2.1 Ecological Preliminary Remedial Goals (PRGs) for Chemical Stressors

5.2.1.1 Aquatic Preliminary Remedial Goals

Preliminary remedial goals for surface water are the national ambient water quality criteria, adjusted for hardness for specified metals (Table 3.2.1.1-1, and respective formulae from U.S. EPA, 1999). However, the estimated 95th percentiles of the background concentrations of lead and zinc may exceed the national ambient water quality criteria in streams in some parts of the Coeur d'Alene River basin. Lead concentrations could exceed the national criteria in the Upper South Fork (CSM Unit 1, Upper South Fork Segment 1) and tributaries, the Page-Galena Mineral Belt (streams draining slopes south of the South Fork between Wallace and Pine Creek; i.e., draining to CSM Unit 2, Segments 1 and 2 from the south), and the entire South Fork of the Coeur d'Alene River basin. Zinc could exceed the national criteria in drainages from the Page-Galena Mineral Belt and the entire South Fork. The 95th percentile background concentrations of lead and zinc in the entire South Fork River basin are estimated at 1.09 and 72 µg/L, respectively (Table 2.3.2-1). PRGs for surface water could be adjusted to reflect background conditions. Adjusted (to background) PRGs would still generally be below significant effects levels indicated by the cumulative chronic toxicity response profiles for lead and zinc (Figures 3.2.1.1-6 and 3.2.1.1-8), but with some uncertainty because of the limited data available to determine responses to chronic exposures to lead. The chronic and acute toxicities of zinc are nearly identical, so the data on acute toxicity of zinc (Figure 3.2.1.1-7) can be used to assess effects of chronic exposure.

where is this

Toxicity-based potential PRGs for sediment are generally exceeded by regional background concentrations of metals in soil (the original source of sediment), so soil upper background values (RI Section 6.3) are recommended as sediment PRGs (Table 3.2.1.2-1). Based on the determinations of regional variations in soil upper background values (RI Section 6.3), background values of cadmium, copper, lead, and zinc could be higher in parts of some upper watersheds (e. g., Canyon Creek) and upper background values of cadmium, lead, and zinc could also be higher in the valley of the South Fork of the Coeur d'Alene River from Canyon Creek to Pine Creek. Possible regional variations (higher) in upper background are: Cadmium in lower Canyon Creek and along the South Fork below Canyon Creek to Pine Creek, to 8.7 mg/kg; copper in lower Canyon Creek, to 63 mg/kg; lead in lower Canyon Creek and along the South Fork, 150 and 196 mg/kg, respectively; and zinc in lower Canyon Creek and along the South Fork, to 1,300 and 630 mg/kg, respectively RI Section 6.3). Samples from deep cores in the lower Coeur d'Alene valley and lateral lakes indicate background values in CSM Unit 3 that are well below the values stated in Table 3.2.1.2-1.

5.2.1.2 Soil-Associated Biota and Wildlife

The Preliminary Remediation Goals (PRGs) for the Coeur d'Alene Basin Remedial Investigation/Feasibility Study (RI/FS) have been presented previously in the Technical

this was not released

So don't reference.

Memorandum - Draft Preliminary Remediation Goals for Wildlife and Soil-Associated Biota (CH2M HILL, 2000)[hereafter referred to as the PRG Technical Memorandum]. The draft PRGs developed in the technical memorandum were the result of more recent work by the EcoRA Group including more specific information concerning receptors, assessment endpoints, and measures. Additional Basin-specific information was also available concerning the occurrence and effects of mining-related chemicals on ecological receptors and their habitats for evaluation of the measures.

The draft PRGs represented both numerous receptors and varying degrees of conservatism. In many cases, the most conservative draft PRGs (i.e., NOAEL-based PRGs for wildlife and NOEC-based PRGs for soil-associated biota) fell below background concentrations in the CDA basin. The 10th percentile for each draft PRG distribution can be used to compare the relative conservatism of the various distributions. It is recommended that the final PRG for a specific area be chosen based upon the degree of protectiveness that is desired, given the nature of receptors and habitats present (i.e., not all receptors occur in each habitat), along with expected land uses. Presentation of multiple PRGs derived by multiple methods will allow for more robust and defendable risk management decisionmaking.

The development of the draft PRGs is summarized below. The specific equations used to derive wildlife PRGs as well as the associated tables and figures can be found in the PRG Technical Memorandum (CH2M HILL, 2000). The associated tables will be incorporated as necessary into the draft EcoRA due out in late August.

will have to select a value that is protective

5.2.1.2.1 Soil-Associated Biota

Draft PRGs for soil-associated biota (e.g., earthworms, plants, and microbial processes) were based on published toxicity data as presented in Efroymson et al. (1997a and 1997b). PRGs based on NOECs and LOECs for each receptor group were presented in the Tables 12-17 of the PRG Technical Memorandum (CH2M HILL, 2000).

5.2.1.2.2 Wildlife PRGs - External Exposures

Draft PRGs for birds and mammals were derived as concentrations of COPECs in soil-sediment that, given species-specific soil and food ingestion rates and diet composition, would result in exposures equivalent to a suitable toxicity reference value (TRV). These PRGs were determined by solving (back-calculating) the general wildlife exposure model presented in Sample et al. (1997) in terms of the COPEC concentration in soil-sediment. The general wildlife exposure model, assumptions, and exposure parameters were presented in the PRG Technical Memorandum (CH2M HILL, 2000) as well as in Section 3.2.1.6.1 of this report. Bioaccumulation factors were estimated using the model presented in the PRG Technical Memorandum using site-specific data wherever possible. In the absence of site-specific data, literature-based models were used. Toxicity information for birds and mammals was presented in Section 3.2.1.1 of this report. The toxicity reference values selected consisted of no and lowest observed adverse effects levels (NOAELs and LOAELs) and EC_{20} values derived from dose-response curve fitting. Multiple toxicity studies were available for both birds and mammals for each analyte. Toxicity studies were selected for application to PRG development if exposure was chronic or during reproduction, the dosing regime was sufficient to identify both a NOAEL and a LOAEL and allow for dose-response curve-fitting, and the study considered ecologically relevant effects (i.e., reproduction, mortality, growth). If multiple studies for a given COPEC met these criteria, the study generating the lowest reliable TRV was selected for PRG development. PRGs were developed for birds and mammals based on NOAELs, LOAELs, and EC_{20}s. These were presented in Tables 4, 5, and 6 of the PRG Technical Memorandum (CH2M HILL, 2000).

5.2.1.2.3Wildlife PRGs - Internal Exposures

Previous research has shown that concentrations of chemicals in small mammal tissues may be estimated based on soil concentrations (Sample et al. 1998, Shore 1995). As an alternative approach for determination of PRGs, soil-to-liver and soil-to-kidney bioaccumulation models were developed for small mammals based on literature-derived data. Using an approach comparable to that employed in Sample et al. (1998), co-located soil and small mammal organ concentration data were extracted from published studies. Log-linear regression models were developed for all small mammals combined and for specific trophic guilds (e.g., insectivores, herbivores, and omnivores). Organ concentrations associated with toxicity were derived from published literature. Target-organ-based draft PRGs for small mammals for cadmium, lead and zinc were presented in Table 10 the PRG Technical Memo (CH2M HILL, 2000).

5.2.1.2.4 Waterfowl PRGs - Site-Specific Sediment Ingestion Model

Site-specific sediment draft PRGs for waterfowl were developed based on an adaptation of the exposure/effects model presented in Beyer and Audet (1999). Site-specific sediment ingestion data for tundra swans, Canada geese, mallards, and wood ducks (Beyer et al. 1998, Beyer et al. 1997) were combined with sediment lead - blood lead or sediment lead - liver lead bioaccumulation models developed for waterfowl fed diets containing sediment from the Coeur d'Alene basin (Hoffman et al. 1999, Heinz et al. 1999, and Day et al. 1998) to generate estimated concentrations of lead in blood and livers of waterfowl. Estimated blood and liver concentrations were then divided by the minimum and 10th percentile concentrations of lead in blood and liver of moribund or dead waterfowl from the Coeur d'Alene basin. Draft lead PRGs for waterfowl were presented in Table 11 of the PRG Technical Memorandum (CH2M HILL, 2000).

5.2.2 Summary of Ecological Status for Physical and Biological Characteristics

[[This subsection will be completed for the draft EcoRA to be submitted in late August. It will summarize the results of the ecological status ranking for portions of the Coeur d'Alene River basin where data were sufficient for evaluation. This information will be presented in detail in Appendix E, which is still under development.]]

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